U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-296 551

Wastewater Treatment Facilities Planning in the Boston Metropolitan Area - A Case Study

Kennedy Engineers, Inc, San Francisco, CA

Prepared for

National Science Foundation, Washington, DC Div of Policy Research and Analysis

Jan 79

APR 1979

ABOUT THIS REPORT

The attached is one of a group of four contractor-prepared reports which collectively comprise Phase II of a government-sponsored study, "Scientific and Technical Evaluation of the Environmental Protection Agency's Wastewater Treatment Facilities Grants Planning Process - Boston Case Study." The study examines current administration of the municipal wastewater treatment facilities construction grants program established by the Federal Water Pollution Control Act Amendments of 1972 and modified by the Clean Water Act of 1977.

The reports were prepared for a federal interagency study team composed of representatives of the National Science Foundation, the President's Council on Environmental Quality, the Office of Management and Budget, and the Environmental Protection Agency headquarters. Draft copies of these reports were made available to the public in August 1978 and were the subject of agency and public meetings in September 1978. Written comments were solicited from governmental agencies, public interest groups, and the general public. They are noted and responded to by the contractors in the final printed reports.

The objective of the study was to examine recent operation of the Construction Grants Program, using the Boston Metropolitan Area as a case study, with a view toward developing recommendations for possible legislative or administrative actions at the national level to (1) improve the administration of the program in general; (2) upgrade the scientific and technical basis for decisionmaking; and (3) assure that federal funds are used in a cost effective way to achieve national water pollution cleanup goals.

The four reports comprising Phase II of this study are

Kennedy Engineers, Inc., Wastewater Treatment Facilities Planning in the Boston Metropolitan Area - A Case Study. Engineering Report. January 1979.

Environmental Research & Technology, Inc., Water Quality Goals, Objectives, and Alternatives in the Boston Metropolitan Area - A Case Study. February 1979.

Environmental Research & Technology, Inc., Sludge Management Planning in the Boston Metropolitan Area - A Case Study. January 1979.

Urban Systems Research & Engineering, Inc., Institutional Aspects of Wastewater Management: The Boston Case Study. January 1979.

Our signatures indicate that this study was conducted under our supervision, but they do not imply our agreement, individually or collectively, with the study findings, conclusions, or recommendations.

Richard E. Morrison
National Science Foundation

David E. Burmaster
Council on Environmental Quality

Jim J. Tozzi
Office of Management and Budget

BIBLIOGRAPHIC DATA SHEET

1. Report No. NSF/PRA-7681772/1

2.

3. Recipient's Accession No. PB296551

4. Title and Subtitle

Wastewater Treatment Facilities Planning in the Boston Metropolitan Area -- A Case Study

5. Report Date January, 1979

6.

7. Author(s) William A. Anderson, Robert M. Kennedy

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

Kennedy Engineers, Inc.
657 Howard Street
San Francisco, California 94105

10. Project/Task/Work Unit No.

11. Contract/Grant No. PRA-7681772

12. Sponsoring Organization Name and Address

Division of Policy Research & Analysis
National Science Foundation
1800 G Street, N. W.
Washington, D. C. 20550

13. Type of Report & Period Covered Final

14.

15. Supplementary Notes The other reports are: Water Quality Goals, Objectives, Alternatives in the Boston Metropolitan Area; Sludge Management Planning in the Boston Metropolitan Area; Institutional Aspects of Wastewater Management - The Boston Case Study.

16. Abstracts

This report is one of four contractor-prepared reports which comprise a Federally-sponsored study, "Scientific and Technical Evaluation of the Environmental Protection Agency's Wastewater Treatment Facilities Grants Planning Process-Boston Case Study." The objective of the study was to examine recent operation of EPA's Construction Grants Program, using the Boston Metropolitan Area as a case study, with a view toward developing recommendations for possible legislative or administrative actions at the national level. This Engineering Report reviews the development and planning of sewerage facilities in Eastern Massachusetts, evaluates the present major treatment works, identifies various pollution problems, examines available local plans, and evaluates technical alternatives. Problems examined include raw sewage discharges, combined sewer overflows, sewage bypasses, and excessive inflow/infiltration. The extent of consolidation and the degree to which water conservation is practical are evaluated. This Case Study indicates that appropriate facilities planning can reduce the scope of new wastewater projects. To optimize planning efficiency, Federal guidelines are needed.

17. Key Words and Document Analysis. 17a. Descriptors

Waste water
Water pollution
Water quality
Water resources
Water treatment
Waste treatment
Environmental engineering
Sewage
Sewage treatment
Sanitary engineering
Project planning
Contract administration
Facilities management
Management planning
Benefit cost analysis

17b. Identifiers/Open-Ended Terms

Combined sewer overflows
Sewage bypass
Inflow/infiltration
Pollution control technologies
Facility planning
Construction planning
Grants management
Federal Water Pollution Control Act of 1972
Clear Water Act of 1977
Boston Harbor

17c. COSATI Field/Group 5A, 5D, 13B, 14A

18. Availability Statement UNLIMITED

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages 748

22. Price $21.50

PB 296551

WASTEWATER TREATMENT FACILITIES PLANNING IN THE BOSTON METROPOLITAN AREA – A CASE STUDY

Engineering Report

Submitted to the
Federal Interagency Study Team:

National Science Foundation
Council on Environmental Quality
Environmental Protection Agency
Office of Management and Budget
Contract NSF C76-81772

January 1979

KennedyEngineers
San Francisco

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

ENGINEERING REPORT CONTENTS

Title	Chapter
Introduction	i
Executive Summary	S
Historical Development of Boston Area Wastewater Facilities	1
Deer and Nut Island Treatment Plants	2
Analysis of EMMA Study	3
Raw Sewage Discharges	4
Combined Sewer Overflows	5
Infiltration/Inflow	6
Extent of Consolidation	7
Water Conservation	8
Criteria and Procedures	9
Alternatives	10
Distribution List	D
Comments	C

This material is based upon research supported by the National Science Foundation under Contract No. C76-81772. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation, the Council on Environmental Quality, the Environmental Protection Agency, or the Office of Management and Budget.

INTRODUCTION

This Engineering Report is a case study of the Environmental Protection Agency's Wastewater Treatment Facilities Planning Process in the Boston Metropolitan Area. The objective of this Report is to document and examine, on the basis of the administration of the Clean Water Grant Program, the events and actions by Region I of the EPA and the many other agencies involved in facilities planning in Eastern Massachusetts, exclusive of sludge Management. It is neither mandated nor intended to affect the local decision-making process; instead it is only to study it for purposes of identifying issues of possible National significance.

This Report records the historical development of sewerage facilities in the Study Area, and presents an examination of the major treatment works and proposed technical alternatives which have been advocated to correct the various pollutional problems.

Problems examined in this Case Study include raw sewage discharges, combined sewer overflows, sewage bypasses, and excessive inflow/infiltration. The extent of consolidation and the degree to which water conservation is practical in the Study Area are evaluated. The importance of a sound data base for planning is discussed. The Study includes a review of grants procedures and criteria for administration of the funding program. An assessment of the needs of the Study Area is made and compared with funding.

This Study is a component part of Phase II of a broader series of Studies collectively examining wastewater facilities planning issues in the

Boston Metropolitan Area. The series of Studies were undertaken by a Federal Interagency Study Team composed of representatives from

Office of Management and Budget (OMB)
National Science Foundation (NSF)
Council on Environmental Quality (CEQ), and
Environmental Protection Agency (EPA).

This Phase II series of studies follows a set of Phase I studies undertaken in the spring of 1976 by the same Federal Interagency Study Team. The Phase I studies were instituted to record local sources of available data and to aid in identifying issues for further study, as follows:

Kennedy Engineers, Inc., San Francisco
"Phase I Engineering Report, Boston Case Study"
July 28, 1976
Prepared for National Science Foundation

Resource Analysis, Incorporated, Cambridge
"Phase I Water Quality Considerations"
July 30, 1976
Prepared for Council on Environmental Quality

Urban Systems Research & Engineering, Inc., Cambridge
"Wastewater Management Planning: Boston Metropolitan Area, Phase I Study"
July 16, 1976
Prepared for Council on Environmental Quality

The Vertex Corporation, McLean Virginia
"Phase I Final Report on Greater Boston: Water-Quality Issues in Planning for Pollution Control"
August 6, 1976
Prepared for National Science Foundation

The location of this case study was selected by the Federal Interagency Study Team, as was the boundary of the Study Area. An explanation of the grant program, which is the subject of the Boston Case Study, together with listing of the local agencies involved in the program and the location of the Study Area is given herein.

CLEAN WATER GRANT PROGRAM

The Municipal Wastewater Treatment Works Construction Grant Program, popularly called the Clean Water Grant Program, is listed in the Catalog of Federal Domestic Assistance as No. 66.418 under the Office of Water and Hazardous Materials of the United States Environmental Protection Agency. It is authorized by Title II of the "Federal Water Pollution Control Act Amendments of 1972" Public Law 92-500 which was enacted October 18, 1972 and referred to hereinafter as PL 92-500. The stated objective of the Clean Water Grant Program is to assist and serve as an incentive in construction of municipal sewage treatment works which are required to meet State and Federal water quality standards.

The form of assistance is grants pursuant to Section 201 of PL 92-500 to plan, design, and build wastewater treatment facilities. A brief summary of the program elements is as follows:

1. Applicant.

   To be eligible for Federal Assistance an applicant must be a public body created under State Law such as a municipality or special district with legal authority for sewage disposal. The applicant must also have authority to plan, design, finance, construct, operate and maintain sewage treatment works.

2. Types of Projects.

   The following types of projects can be eligible for assistance and entitled to an EPA grant equal to 75% of the allowable project costs:

a. Sewage treatment plants,
b. Interceptor sewers,
c. Sewage collection systems, and
d. Combined sewer overflow control systems.

3. Priority List.

Each state is annually allotted a specific sum of money for grants. Projects are to be ranked in priority order by the States to determine which will receive the funds. The applicant's project must be on the active priority list to qualify for a grant.

4. Construction Grant Process.

The construction grants process is adminstered in three steps for each facility as follows:

a. Step 1 is a project to perform planning and preliminary engineering, referred to as "Facility Planning."

b. Step 2 is a project to prepare detailed plans and specifications, and

c. Step 3 is a project for construction of the facilities.

5. Facility Planning.

The grantee prepares Step 1 facility plans pursuant to Section 201 of PL 92-500. Facility plans are to investigate the specific requirements of the planning area, identify pollution problems, evaluate alternatives and recommend a solution. Public participation in the decision making process is also required in Step 1.

6. Clearinghouses.

The Office of Management and Budget requires that all projects financed in whole or in part be reviewed by a State and/or regional clearinghouse.

7. Basin Plans.

States are required to carry out Water Quality Management Plans pursuant to Section 303(e) of PL 92-500. Each basin plan is to determine the level of treatment required for every sewage treatment plant within each river drainage basin.

8. Areawide Plans.

For designated areas, Areawide Waste Treatment Management Plans are undertaken usually in urban or metropolitan areas which have particularly bad water pollution problems, pursuant to Section 208 of PL 92-500. Where an applicant is situated in the designated area and the Areawide Plan is complete, the project must conform with the areawide study recommendations. If the Areawide Plan is not complete the 208 Planning Agency must have an opportunity to comment on any proposed projects in its area.

9. NPDES Permits.

Permits are issued by the States and/or EPA for discharges under the National Pollution Discharge Elimination System (NPDES) pursuant to Section 402 of PL 92-500.

In the Commonwealth of Massachusetts, the 1973 amendments to the "Massachusetts Clean Waters Act," (enacted in 1966) provide that the Commonwealth may make a grant equal to fifteen percent (15%) of the eligible costs of a project approved by the United States Government for a federal construction grant of seventy-five percent under the Federal Water Pollution Control Act. The State Act further provides that where federal funds are unavailable in any fiscal year, and projects are ready for construction, the Commonwealth may make ninety percent grants to agencies which have projects with a total estimated reasonable cost of five million dollars or less.

With these provisions, the successful applicant's local share of funds to build facilities often is as small as ten percent (10%) of the total project cost.

INSTITUTIONS

The agencies involved with the Clean Water Grant Program in the Study Area together with the general scope of involvement for each are as follows:

Environmental Protection Agency, Region 1 (EPA), grant administration, approval of water quality standards, issuance of NPDES permits environmental impact statements (EIS), and enforcement.

Commonwealth of Massachusetts, Division of Water Pollution Control (DWPC), river basin planning, water quality standards, and priority lists. Also permits and enforcement.

The Commonwealth of Massachusetts Office of State Planning (OSP) State Clearinghouse.

Metropolitan Area Planning Council (MAPC), Regional clearinghouse and section 208 areawide planning agency.

Metropolitan District Commission (MDC), the governing agency of the Metropolitan Sewerage District (MSD) which intercepts raw sewage collected by member communities around Boston Harbor and provides sewage treatment and disposal service for them. The District was originally established in 1889. The MDC also is a sponsor of the Boston Harbor - Eastern Massachusetts Metropolitan Area Wastewater Engineering and Management Plan (EMMA Study).

Thirteen Cities and thirty Towns are present members of the MSD. Each provides sewage collection service to its users and conveys raw sewage to the MSD interceptors.

South Essex Sewer District (SESD) is a regional agency in the North Coastal Basin established in 1925 to serve the Cities of Beverly, Peabody and Salem and the Towns of Danvers and Marblehead.

Charles River Pollution Control District (CRPCD) is a regional agency in the upper Charles River Basin established in 1973 to serve the communities of Franklin, Medway and Bellingham.

Two other Cities and fifty-six other Towns in the Study Area which have no sewerage facilities, have their own community sewerage faciltiies or in some cases have joint use facilities.

Boston Redevelopment Authority (BRA) is also a potential applicant and grantee for the sewer separation portion of redevelopment projects in Boston.

U.S. Army Corps of Engineers (C of E), New England Division, participated in the EMMA Study.

Boston Harbor Citizens' Advisory Committee (CAC), Consultants and Members of the Public are also involved and participating in the Facilities Planning Process of the Clean Water Grant Programs of the Study Area.

PHASE II REPORTS

Other case study reports prepared concurrently for the Federal Interagency Study Team are:

Sludge Management Planning, and An Analysis of Water Quality Goals and Objectives, both by Environmental Research and Technology, Inc., and Political and Institutional Issues, by Urban Systems Research & Engineering, Inc.

Data gathering for this report ended December 1976.

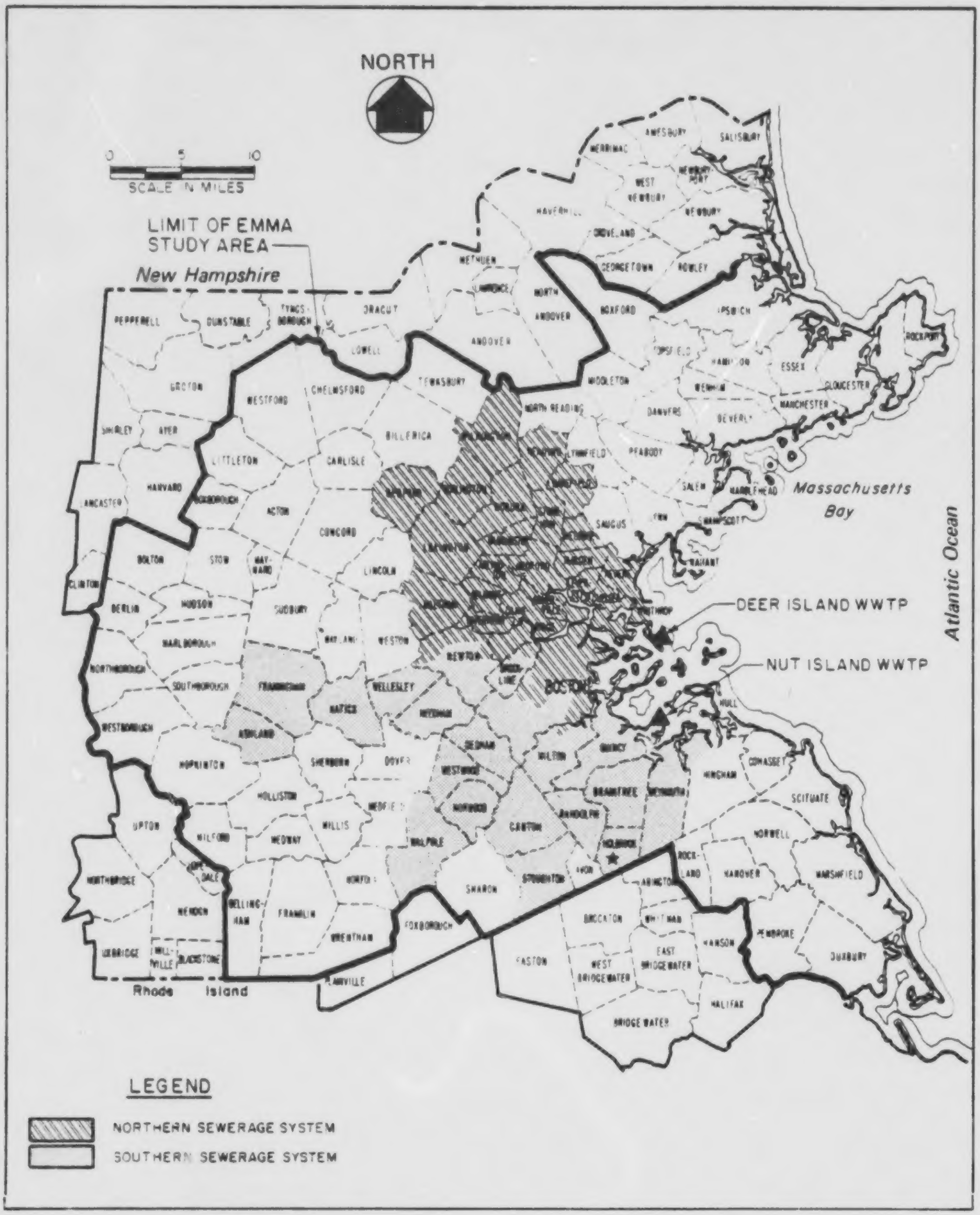
THE BOSTON SETTING

The study area is given as the 109 Cities in and around the Greater Boston Metropolitan area of Eastern Massachusetts, the same as that of the EMMA Study, with emphasis placed on the Metropolitan Sewerage District service area. The study area comprises 1600 square miles extending south of the Blue Hills and Rhode Island, past Arlington Heights nearly to New Hampshire to the north, and about 35 miles from Boston to the west, as shown on Figure 1. The 1970 population of the study area was over three million, more than half that of the Commonwealth. More than two million of the population are in the Inner Core area around the City of Boston; the remainder of the area is sparsely populated, wooded countryside.

The area is gently sloping toward the coast with little fall in the rivers. The highest elevation is approximately 350 feet above sea level. Soils vary from glacial tills and outwashes to tidal marshes, underlain with crystalline bedrock. Precipitation averages about forty-four inches annually, evenly distributed throughout the year.

A transect across the study area passes from headwaters and rural areas through suburbs into the urban core area to the coast. The four largest rivers in the area have several dams on them and are tidal in the lower reaches. They discharge into Boston Harbor, thence past islands in Massachusetts Bay to the Atlantic Ocean.

The study area generally encompasses eight river basins of which five are tributaries of Boston Harbor, three drain directly to the Atlantic Ocean, and one (the SuAsCo) drains to the Merrimack River. 645 square miles of watershed drain into Boston Harbor.


NORTH
0 5 10
SCALE IN MILES
LIMIT OF EMMA STUDY AREA
New Hampshire
Rhode Island
Massachusetts Bay
Atlantic Ocean
DEER ISLAND WWTP
NUT ISLAND WWTP
BOSTON
LEGEND
NORTHERN SEWERAGE SYSTEM
SOUTHERN SEWERAGE SYSTEM

AREAS SERVED BY THE EXISTING METROPOLITAN INTERCEPTOR SYSTEMS AND THE DEER AND NUT ISLAND WASTEWATER TREATMENT PLANTS

NSF Boston Case Study, Phase II Evaluation

STUDY AREA

Kennedy Engineers, Inc.
1977

Figure **1**

Source: MDC EMMA MAIN REPORT, Metcalf & Eddy, March 1976

EXECUTIVE SUMMARY

Wastewater Treatment Facilities Planning in the Boston Metropolitan Area

A Case Study

(As of December 1976)

Preface

This report is a component of a series of studies examining the wastewater facilities grants planning process in the Boston Metropolitan Area. The studies were undertaken by a Federal Interagency Study Team composed of representatives from:

Office of Management and Budget (OMB),
National Science Foundation (NSF),
Council on Environmental Quality (CEQ), and
Environmental Protection Agency (EPA).

The series of studies is collectively called "Scientific and Technical Evaluation of the Environmental Protection Agency's Wastewater Treatment Facilities Grants Planning Process - Boston Case Study."

Introduction

This is the Executive Summary of the Engineering Report which reviews the historical development and planning process for sewerage facilities in Eastern Massachusetts, evaluates the present major treatment works, identifies various pollution problems, examines available local plans, and evaluates technical alternatives, exclusive of Sludge Management Considerations.

The case study also focuses on the EPA's administration of the Clean Water Grant Program, authorized October 18, 1972 by Title II of the Federal Water Pollution Control Act Amendments - Public Law 92-500. The objective of that program is to assist and serve as an incentive in construction of municipal sewage treatment works which are required to meet State and Federal water quality standards.

Project alternatives which are broader in scope than those being considered locally are analyzed and compared. Some alternatives presented are not fully consistent with provisions of the Clean Water Grant Program guidelines in effect at the end of 1976, but are included to highlight policy issues of possible national significance. It is emphasized that the data base for this case study stops as of December 1976.

It is recognized that planning for wastewater facilities began before Public Law 92-500 was enacted. It is also recognized that the grant program originally was administered under different rules and regulations than those in effect at the time the case study was conducted. Analysis of the administration of the facilities planning process was influenced by the following developments:

In 1972, Public Law 92-500 mandated facilities planning as the first step of the Clean Water Grant Program. During the course of this case study there was no facilities plan or EIS available for the regional system being studied which could be examined for conformance with the law.

It is recognized that facilities planning efforts have been initiated after 31 December 1976, the cutoff date for input to this Report.

This Report is based on the available literature, reports, records, observations and on interviews with officials and staff in the wastewater facilities planning process in Eastern Massachusetts. Principal sources of information included the New England Region of EPA, The Commonwealth of Massachusetts Division of Water Pollution Control, The Metropolitan Area Planning Council, and The Metropolitan Sewerage Division of the Metropolitan District Commission.

The stated objective of the Federal Water Pollution Control Act "is to restore and maintain the chemical, physical, and biological integrity of the Nation's Waters." We find that the planning process in the Boston Area has emphasized implementing secondary treatment for treated waste discharges into Boston Harbor. This approach is mandated nationwide but it is not certain that it will enhance water quality in Boston Harbor. On the other hand, we find a lack of adequate policy directed toward reducing the observed pollution of rivers and shoreline areas due to direct raw sewage discharges, overflows and bypasses, and to the subject of water conservation and wastewater flow reduction.

Disclaimer

This material is based upon research supported by the National Science Foundation under Contract No. C76-81772. Any opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the National Science Foundation, the Council on Environmental Quality, the Environmental Protection Agency, or the Office of Management and Budget.

Basis of Study

Before passage of the Clean Water Grant Program, Public Law 92-500, the Metropolitan District Commission (MDC) provided all regional wastewater facilities in the Metropolitan area. Since that time nearly all the planning, design, and construction of the facilities for this area has been accomplished without funding assistance from the Clean Water Grant Program.

Special reports and documentation are required by the Environmental Protection Agency (EPA) to satisfy the program. As a result, the planning and design performed independently from the program are not in conformance with its regulations and criteria.

The "Wastewater Engineering and Management Plan for Boston Harbor - Eastern Massachusetts Metropolitan Area Study" (known as EMMA Study) was accepted and designated by EPA as the Water Quality Management Plan (or Basin Plan) for Boston Harbor. However, EMMA was prepared by MDC for their own use in future facilities planning, and information which is required in Basin Plans is not part of that study.

To conform with EPA regulations for grant funding for water pollution control facilities, a complete Project Report is required which will show that the total project is the most cost-effective project to achieve pollution control objectives. In addition, the NPDES Permits issued by EPA allowing bypasses and overflows need revision to include discharge quality levels.

This Case Study is based on the following premise:

> the most important basic concept of facilities planning is the conveyance of all wastewater to a treatment plant, and all treated effluent to an acceptable point of disposal. At the same time, excessive amounts of extraneous flows which do not require treatment must be excluded from sewers.

The following list of major findings is based on data available as of December 31, 1976, and itemizes those conditions which limit the efficiency of the wastewater facilities which existed at that time in Metropolitan Boston.

A. HISTORICAL BACKGROUND

1. Many different kinds of municipal wastewaters discharge into Boston Harbor, its tributary rivers, and the Atlantic Ocean. The discharges vary from continuous and intermittent untreated sewage to effluents from primary, secondary, and tertiary treatment plants. Most of the existing sludge and scum solids are also discharged with the effluents. In addition, overflows from the combined sewer systems frequently occur, most of them having little or no treatment. By 1962 there were 14 municipal wastewater treatment plants in the Study Area. Today there are 21 plants in operation, and only one of them uses land disposal. They include municipal plants providing one or more sewered communities with a wide range of treatment levels. MDC operates the two largest primary treatment plants: at Deer Island and at Nut Island.

2. From the beginning of the Clean Water Grant Program through fiscal year (FY) 1976, there were more funds available than eligible projects. However, in FY 1977 the number and cost of potentially grant eligible projects exceeded the remaining grant funds available.

3. An Areawide Waste Treatment Management Plan is being prepared by Metropolitan Area Planning Council (MAPC) under Section 208 of Public Law 92-500. However, the Plan will be completed after individual projects within the area are planned to be funded under Section 201. Section 201 grant funds are presently allotted and obligated to projects independent from a completed areawide plan. (The Draft 208 Plan is reported to have been released August 1978.)

4. The EMMA Recommended Plan provides for expanding the MSD service area from 208 to 293 square miles. This service area includes 51 communities around Boston Harbor, eight more than are served at present. Fifty-eight other communities located in the peripheral part of the Study Area are not included in the Recommended Plan.

B. DEER ISLAND SYSTEM

1. The Deer Island primary treatment plant discharges to President Roads section of Boston Harbor; daily flows are reported to average 329 million gallons per day (mgd) during MDC FY 1975-1976. The average daily flows range from approximately 200 to 500 mgd. The peak hourly flow rate is 520 mgd. The daily plant effluent, excluding sludge solids, contains the following mass emissions to Boston Harbor:

260,000	pounds of BOD
210,000	pounds of Suspended Solids
43,000	pounds of Grease
8.6	million^2 Coliforms
1,100	pounds of Residual Chlorine

Considerable additional loading would be discharged by the plant if the headworks did not divert raw sewage to overflows, due to restricted pumping capacity at the treatment plant.

2. The Deer Island pumps are inadequate for conveying sewage from the member communities to the treatment plant, particulary during high tide and during periods of wet weather. As a result, it is frequently necessary to limit the influent at the headworks, causing backup and overflows of untreated wastewater throughout the sewerage system.

3. The Deer Island Plant discharges sludge and scum with the effluent during ebb tides. During FY 1975-1976, sludge and scum amounted to between 65,000 and 100,000 pounds per day of total solids, of which about 48 percent were volatile solids. The BOD and bacterial content of the discharged sludge are unknown. An estimated sludge BOD concentration of 25,000 mg/l indicates an additional 67,000 pounds per day BOD loading to President Roads. If the sludge solids discharge is eliminated, total emissions of solids from Deer Island will be reduced by approximately 30 percent.

4. The practice of disposing of snow into the combined sewers encourages ice formation on the surface of the sedimentation tanks at Deer Island. The resulting structural damage to the sludge and scum removal mechanisms causes tanks to be shut down for repairs. Only six of the eight tanks were operable during half of FY 1975 and only four tanks were usable during extreme conditions.

5. Present flows and influent loadings for the Deer Island plant are less than the effluent limits set by the NPDES permit. The terms of the permit are such that greater influent loading in turn allows more effluent emissions. Thus a considerable amount of additional flow and/or even more concentrated wastewater can be discharged, and still comply with NPDES permit effluent limitations.

6. EMMA Recommended Plan for the Deer Island plant includes upgrading and capacity increase to accommodate an average daily flow of 400 mgd.

This Case Study estimates the cost of this repair is equivalent to less than one-half the cost of a new primary treatment plant. Plant reliability could be improved by covering the sedimentation tanks. In addition, top priority should be given to restoring full pumping capacity and then providing peak flow-rate treatment capability of over one billion gallons per day. Consideration should be given to building a new pumping station to handle flows from the Boston Main Drainage Tunnel and converting the existing pump station to pump only from the North Metro Relief Tunnel. This would require enlarging Ward Street and Columbus Park headworks and further expanding plant primary treatment capacity.

Other major items needed, but not included in the EMMA plan are: additional chlorine contact chambers, additional capacity in the outfall and diffuser systems, improvements to the chlorine diffusion, a mixing and control system, flow measuring systems, instrumentation, a reclaimed water system, screenings equipment, headgates, sampling systems, and other miscellaneous plant improvements to aid operation, improve safety, and increase reliability.

Management improvements should include the full use of existing pumping capacity for facilities at both the main pumping plant and the Winthrop Terminal, daily performance sampling and monitoring, development of a viable contingency plan to avoid plant shutdowns, and formal on-going programs for training and certification of the staff.

7. Pilot plant treatability studies are recommended prior to selection of the secondary treatment process at Deer Island because of the highly variable influent loadings that include rapidly changing chloride concentrations.

C. NUT ISLAND SYSTEM

1. The Nut Island primary treatment plant processed an average daily flow of 123 mgd during FY 1975-1976. The sewage effluent contained the following estimated average daily emissions to Nantasket Roads, a section of Boston Harbor:

124,000	pounds of BOD
116,000	pounds of Suspended Solids
23,000	pounds of Grease
2,800,000	millions Coliforms
1,300	pounds of Residual Chlorine

The amount of sewage bypasses and overflows from the Nut Island system is not measured.

2. Sludge, together with a portion of the sewage effluent, is discharged from Nut Island to President Roads section of Boston Harbor. The average daily sludge discharge during FY 1975-1976 was 217,000 gallons per day. The sludge discharge contains an estimated 40,000 pounds per day of total solids of which 58.7 percent are reported to be volatile solids.

3. The Nut Island plant is overloaded. The average flow into it exceeds the rated capacity of the plant. During FY 1975, as few as three of the six sedimentation tanks were in service for more than half the time. The plant is in very poor condition because of its age and severe deterioration.

The MDC construction staging program shows the Nut Island primary treatment improvements will be completed in the summer of 1984. At that time the major treatment units of the existing plant will be 34 years old. The Nut Island facilities are now critically in need of repair, restoration, and upgrading. Expansion is also needed but there is insufficient space for it on the site.

4. EMMA Recommended Plan specifies $50.5 million for primary treatment improvements to the Nut Island plant. The cost involved is as great as would be required to construct an entirely new primary treatment plant at a different location exclusive of land cost. Consequently it appears cost-effective to abandon the Nut Island site and build a new plant at a different site.

5. There are no effluent limitations stipulated in the NPDES permit for the expanded Nut Island primary treatment plant. Effluent limits become effective July 1, 1985 and are for secondary treatment.

D. SLUDGE MANAGEMENT

The first priority of the EMMA Recommended Plan is a sludge management project for the existing Deer Island and Nut Island primary treatment plants. A project report, "A Plan for Sludge Management", was completed in 1973 by MSD. The project is stalled in the design phase until the requirements of the National Environmental Policy Act are satisfied. Refer to "Sludge Management Planning in the Boston Metropolitan Area - A Case Study" by Environmental Research & Technology, Inc.

E. DRY WEATHER FLOW MANAGEMENT

1. EMMA Recommended Plan for dry-weather flow management includes projects to upgrade and expand existing facilities of the Deer Island and Nut Island systems. The service area tributary to Nut Island would be reduced. New advanced waste treatment (AWT) facilities would be added at satellite areas on the Middle Charles River and the Upper Neponset River. The average daily flow capacity of the treatment works would be:

Treatment Facility	MGD
Secondary Treatment at Deer Island	400
Secondary Treatment at Nut Island	130
AWT at Middle Charles River	31
AWT at Upper Neponset River	25
Total	586

This capacity is expected to serve 2,440,000 persons in the year 2000 and is equivalent to 240 gallons per person per day.

2. The cost estimated in the EMMA Report for all the facilities contained in the EMMA Recommended Plan, when categorized according to the nationwide Needs Surveys, is as follows:

Facilities Category		$ Million
I	Secondary Treatment	433.8
II	More Stringent Treatment	39.7
IIIA	Infiltration/Inflow Correction	2.0
IIIB	Major Sewer System Rehabilitation	0
IV A	New Collector Sewers	0
IV B	New Interceptors	109.9
	Subtotal	585.4
V	Correction of Combined Sewer Overflows	270.0
VI	Stormwater Treatment and/or Control	0
	Total	$855.4 million

This is equivalent to $351 per capita and does not include the cost of facilities to be provided by individual cities.

F. NATIONWIDE NEEDS SURVEY

1. Data from the Nationwide 1976 and 1978 Needs Surveys prepared by EPA show the costs for needed publicly-owned treatment facilities in the Metropolitan Sewerage District and for all communities in the MSD expanded service area based on 1990 population. They are as follows:

Category		$ Million
I	Secondary Treatment	416.0
II	More Stringent Treatment	77.8
IIIA	Infiltration/Inflow Correction	0.9
IIIB	Sewer System Rehabilitation	45.0
IV A	New Collector Sewers	109.9
IV B	New Interceptor Sewers	153.3
	Subtotal	802.9
V	Combined Sewer Overflows	198.2
VI	Stormwater Control*	1,912.5
	Total	$2,913.6

Estimates for peripheral area communities and regional service agencies other than MSD are $443.9 million.

The 1976 Needs Survey cost estimates for the expanded MSD service area are $410 per capita for categories I through V and $1,194 per capita for all categories. In comparison, cost estimates in the 1974 Needs Survey for Massachusetts were $420 per capita for categories I through V and $863 per capita for all categories.

2. The need for wastewater facilities was reported by the Metropolitan Area Planning Council 208 project, the EMMA Report, and results from the nationwide 1976 Needs Survey. Data from these sources were compared together with other local engineering reports and they indicate that grant eligible costs of needed municipal wastewater facilities easily exceed 3.4 billion dollars at present cost levels. That amount is equivalent to approximately $1400 per capita.

G. RAW SEWAGE DISCHARGES

An approximation of the amount of continuous raw sewage discharges occurring in the Study Area is shown below:

Parameter	Emission	Units
Average daily flow	52	mgd
Peak flow rate	125	mgd
BOD	102,500	pounds per day
Suspended Solids	102,500	pounds per day

Significant intermittent overflows and bypasses are reported to occur but an assessment of the magnitude cannot be made from available data.

*(PL 95-217 discontinues grant eligibility of facilities for stormwater pollution control, according to EPA.)

H. COMBINED SEWER OVERFLOWS

1. An assessment of combined sewer overflow problems for the study area has not been found. There are 900,000 persons in the older portions of Boston, Brookline, Cambridge, Chelsea, and Somerville who are served with combined sewers for sanitary sewage and stormwater. During dry weather, the flows are intercepted by the Metropolitan Sewerage District facilities and normally given primary treatment at Deer Island. During any significant rain storm, the combined sewage overflows from several hundred points to the nearest watercourse. Overflows occur in communities with combined sewers. Overflows also occur from the MSD interceptors and from sanitary sewers of upstream communities at treatment plant headworks, due to inadequate downstream capacity.

2. The quality and quantity of combined sewage is highly variable. Combined sewage often has approximately the same BOD as sanitary sewage, with suspended solids over ten times higher than sanitary sewage. Objectionable constituents, including toxic substances, vary in their concentration with time between storms. In addition, combined sewage is very difficult to handle or treat due to rapid flow variations and massive quantities of debris, grit, and floatables, constituents not usually measured in normal sampling techniques.

3. Efforts to solve pollution problems with the construction of sewage treatment plants have not been successful because there is inadequate capacity in the transport system to convey unregulated peak flows to the plants. Facilities allowing wet-weather overflows from combined sewer systems into the waterways were built and are still necessary to reduce the flooding of streets and backup into homes. Such overflows have been reported as the major factor preventing Boston Harbor and its impoundments and estuaries from meeting recreation, fish and wildlife, and aesthetic water quality criteria.

Effluent limitations for the combined sewer overflow regulation facilities have not been established, and data are unavailable for concentration levels of toxic materials in overflow discharges. Facilities similar to those at the existing MDC Cottage Farm Detention and Chlorination Station in Cambridge, which have not proved effective, have been used as a basis for preliminary cost estimates in the EMMA Report for needed combined sewer overflow regulation projects. Other means of overflow pollution prevention appear necessary although their costs cannot be estimated.

4. It appears that combined sewer overflow works such as the Cottage Farm facility (and probably the Charles River Estuary facility) will allow discharge of more than 85 percent of pollutants at rated capacity. Fifteen percent removal is considered inadequate treatment for combined sewage. The Somerville facility is even less efficient. The performance data from the two operating facilities are insufficient to provide a basis for predicting performance of future similar combined sewer overflow treatment facilities at design capacity.

From the information available, the facilities appear incapable of providing either adequate pollutant removal or disinfection at their rated capacity.

5. The EMMA Recommended Plan proposes four projects for combined sewer overflow regulation. The projects are intended to reduce overflow problems in Dorchester Bay, the Charles River, Neponset River, and Boston Inner Harbor, but the facilities of the type proposed have not been shown effective in pollution removal. These projects are not based upon effectiveness in meeting discharge or water quality criteria. No MDC projects are planned to correct combined sewer overflow problems existing in Norwood, Revere, Stoneham, Waltham, as well as Milford and other peripheral area communities in the North Coastal region.

6. The EPA, jointly with the Massachusetts Division of Water Pollution Control, has been instrumental in establishing the process and the hydraulic capacity to be used for combined sewer overflow projects to be designed and constructed in the future. The NPDES Permit and the Enforcement Compliance Schedule Letter require projects to be of a size such that "untreated" discharges will not occur due to rainfalls of less than a storm of one-year severity and six-hour duration. No effluent limits are established for discharges and the treatment levels are not defined.

7. The rationale of allowing untreated overflows to continue in excess of those caused by one-year, six-hour storms has not yet been subjected to a cost-effectiveness analysis, as required by regulations.

8. The NPDES requirements appear deficient regarding combined sewage in the following four areas:

> First, it is not stated how much, if any, of the combined wastewater should be retained and reconveyed to the Deer Island Treatment Plant;
>
> Second, the "effluent limits" do not contain specific requirements or even guidelines for removals to be obtained in the treatment process, limiting standards to be met in the effluent, nor standards to be achieved in the receiving waters. The degree of disinfection to be achieved or the upper limit of chlorine residual in the effluent also are not given;
>
> Third, the permit mandates, in a general way, the process and three specific unit operations which must be used even though the process has not proved effective in removing pollution loadings; and
>
> Fourth, the "best practicable control technology currently available" mentioned in the NPDES Permit issued to the Metropolitan District Commission has not yet been defined as of the end of 1976.

I. INFLUENCE OF EPA

1. EPA is encouraging design of individual projects before a Facilities Plan for the entire area is prepared. As a result, an evaluation of the cost-effectiveness and water pollution control needs cannot be made.

2. EPA regulations require grant applicants to make an infiltration/inflow (I/I) analysis to demonstrate whether excessive I/I exists in each sewer system tributary to grant assisted treatment works; the applicant must then proceed with a sewer system evaluation (field) survey, where indicated, to determine the cost of rehabilitation versus the cost of transportation and treatment of each source of I/I. This has not yet been done in MSD.

3. The NPDES Permit specifies system capacities which include high I/I allowances. Very high rates of infiltration into Boston area sewers have been documented since the last century. The EMMA Study predicts a unit infiltration allowance of 30 to 120 gallons per capita per day and more in some of the old downtown areas. EMMA Recommended Plan would provide relief sewers and extra treatment capacity due to peak infiltration rates of 200 mgd at Deer Island and 120 mgd at Nut Island.

Planned capacity allowances of average daily flow from extraneous sources, in mgd, are:

	Deer Island System	Nut Island System	Total
Infiltration	129	58	187
Inflow	41	10	51
Total I/I	170	68	238

This I/I allowance for non-sewage amounts to an average of 116 gallons per capita per day in the Deer Island system and 87 gallons per capita per day in all of MSD. Data are not available to confirm that these high allowances are adequate to handle present I/I flows.

4. According to the NPDES Permit, Facilities Planning will be completed and design on the treatment plant expansion projects will start before the I/I evaluations have determined whether it is more cost-effective to treat extraneous flow than to rehabilitate the sewers and interceptors.

5. During 1976, U.S. EPA issued memoranda to the Regions which would encourage less costly wastewater facilities in small communities. A draft memorandum was issued June 1977 that would make septic tanks conditionally grant eligible. Previously, there was a lack of consideration of alternatives to conventional sewers and treatment facilities and consolidation practices.

Refer to "Institutional Aspects of Wastewater Management: The Boston Case Study" by Urban Systems Research and Engineering, Inc.

J. INFILTRATION/INFLOW

1. More than 100 tide gates, intended to keep seawater out of sewers, are located on combined sewer outlets in the tidal zone. Continued tide gate malfunction and backflow over subsided non-gated overflow weirs allow enormous quantities of direct inflow from these sources. The saltwater inflow restricts normal plant inflow at high tides and necessitates choking of headgates with resultant overflows of untreated wastewater. An unknown amount of inflow occurs at ungated overflow weirs which are located below maximum tide level.

2. A program for the replacement of existing deteriorated combined sewer trunk lines is an immediate necessity. Such replacement would permit concurrent separation of sanitary sewers and storm sewers and would reduce stormwater inflow more than 50 percent and eliminate the need for most or all combined sewer overflow tide gates and overflow weirs which are a major source of inflow. It is reported that some trunk sewers are over half filled with sediment, for which capacity could be restored by cleaning.

3. There are insufficient data available at the present time to accurately estimate costs for sewer rehabilitation that would reduce I/I and correct the tide gate problems. The EMMA Recommended Plan does not contain a project for such rehabilitation work, nor is such work included in the cost estimates. This is due partly to jurisdictional problems.

4. Several communities in the Study Area apparently want to continue using individual septic tank systems or, if necessary, to have their own community sewerage system. The MAPC and EPA Headquarters in Washington tend to support, or at least recognize, this position as worthy of further analysis.

On the other hand, MDC is suggesting to offer sewerage service to unsewered communities as part of a large consolidated centralized system in spite of present problems in accepting peak flows. EPA Region I and the State DWPC support this position as documented in the companion report on political and institutional issues by Urban Systems Research Engineering, Inc. There is disagreement among planning agencies whether communities which are presently unsewered should have their own facilities, if they should annex to a regional agency, or if they should remain unsewered.

5. The MAPC and the 1976 Needs Survey both show that sewers are not now required for four of the eight towns to be annexed to the MSD under the EMMA plan. No documented wastewater problems in these eight communities were disclosed in the study, although other towns in the Boston Harbor watershed that have problems are not served.

J. INFILTRATION/INFLOW

1. More than 100 tide gates, intended to keep seawater out of sewers, are located on combined sewer outlets in the tidal zone. Continued tide gate malfunction and backflow over subsided non-gated overflow weirs allow enormous quantities of direct inflow from these sources. The saltwater inflow restricts normal plant inflow at high tides and necessitates choking of headgates with resultant overflows of untreated wastewater. An unknown amount of inflow occurs at ungated overflow weirs which are located below maximum tide level.

2. A program for the replacement of existing deteriorated combined sewer trunk lines is an immediate necessity. Such replacement would permit concurrent separation of sanitary sewers and storm sewers and would reduce stormwater inflow more than 50 percent and eliminate the need for most or all combined sewer overflow tide gates and overflow weirs which are a major source of inflow. It is reported that some trunk sewers are over half filled with sediment, for which capacity could be restored by cleaning.

3. There are insufficient data available at the present time to accurately estimate costs for sewer rehabilitation that would reduce I/I and correct the tide gate problems. The EMMA Recommended Plan does not contain a project for such rehabilitation work, nor is such work included in the cost estimates. This is due partly to jurisdictional problems.

4. Several communities in the Study Area apparently want to continue using individual septic tank systems or, if necessary, to have their own community sewerage system. The MAPC and EPA Headquarters in Washington tend to support, or at least recognize, this position as worthy of further analysis.

On the other hand, MDC is suggesting to offer sewerage service to unsewered communities as part of a large consolidated centralized system in spite of present problems in accepting peak flows. EPA Region I and the State DWPC support this position as documented in the companion report on political and institutional issues by Urban Systems Research Engineering, Inc. There is disagreement among planning agencies whether communities which are presently unsewered should have their own facilities, if they should annex to a regional agency, or if they should remain unsewered.

5. The MAPC and the 1976 Needs Survey both show that sewers are not now required for four of the eight towns to be annexed to the MSD under the EMMA plan. No documented wastewater problems in these eight communities were disclosed in the study, although other towns in the Boston Harbor watershed that have problems are not served.

K. CONSERVATION

Little or no consideration seems to have been given to implementing programs in the Study Area that would reduce the amount of wastewater from residential, commercial and industrial establishments and, therefore, allow smaller size wastewater facilities.

L. ENVIRONMENTAL IMPACT

1. Preparation of an Environmental Impact Statement (EIS) on the major individual EMMA Study Projects has begun under the direction of the EPA (a Draft EIS was released August 4, 1978). The scope includes the siting of new Deer Island and Nut Island plants, questions about sludge management facilities and the need for satellite advanced waste treatment plants. The usual EPA procedure is to prepare an EIS based on a facilities plan. Because there is no facilities planning document to complement the EMMA Study it is doubtful that the EIS can effectively satisfy the National Environmental Policy Act.

There are topics pertaining to the proposed projects which are not included in the scope of the EIS now being prepared. Items which we consider of technical significance are:

a. The unit wastewater criteria for facility design, including I/I allowance.

b. The method of handling combined sewer overflows and if treated, the degree of treatment required and where effluent should be discharged.

c. The extent of Metropolitan Sewerage District expansion.

2. There appear to be no criteria to limit the size of grant eligible facilities or their design period for ultimate capacity. (It is noted however, that this subject is included in new rules and regulations effective October 1, 1978.)

3. Inadequate data exist for rational planning and design of facilities. The lack of an adequate data base regarding sources of wastewater in the MDC Service area has created the need for assumptions that may result in overdesign of facilities.

4. Inadequate data are available to determine if individual sections of the program are cost-effective with respect to the entire regional system. Cost-effectiveness analyses have been limited to individual predetermined projects only.

M. ALTERNATIVE ANALYSIS

1. Three categories of Alternative projects are presented and analyzed as part of this Case Study. The Alternatives are shown on Figure S.

Category I

A basic program to upgrade existing wastewater facilities is proposed with arbitrary limitations for service area, population growth, flow allowances, and other criteria. The purpose of these alternatives is to determine the size and cost of facilities including sewer repair based on amount of flow and service area expansion, but without secondary treatment.

Category II

The proposed wastewater management plan for the Eastern Massachusetts area, known as the "EMMA Recommended Plan", is analyzed to determine the cost-effectiveness of its facility size.

The options in this category include increased primary treatment and funding of the EMMA Plan with possibly reduced grant fundability.

Category III

Ten alternatives to the EMMA Recommended Plan are presented that indicate costs and effects of different configurations of sub-regional systems, four treatment levels, and five discharge locations.

Refer to "An Analysis of Water Quality Goals and Objectives in the Boston Metropolitan Area" by Environmental Research & Technology, Inc.

N. RESULTS OF CASE STUDY

1. The locally proposed plan for wastewater management in the Boston Metropolitan area, Alternative II A, is estimated to cost $855.4 million. Most of this amount is planned for treatment and disposal and does not include new sewers or sewer rehabilitation. Seventy-five percent of the capital cost is ordinarily funded by a Federal grant and, in the Commonwealth of Massachusetts, an additional 15 percent is funded by a State grant. The basic alternative to the EMMA Plan of upgrading the existing facilities are developed with the following constraints:

a. The service area is not expanded and the growth in the existing service area is limited to 30 percent (Alternatives 1A and IB only).

b. The per capita domestic wastewater flows are reduced from the higher proposed amount to 85 gallons per day or the present amount, whichever is less.

c. The excessive infiltration/inflow is reduced to 30 gallons per capita per day, which is one-fourth of that proposed.

d. Secondary treatment is not provided.

Alternative IC, developed without growth constraints, costs approximately one-half as much as the EMMA Plan, Alternative IIA.

2. The flow to be treated in accordance with the constraints in Alternative IC is 348 mgd. The flow to be treated in categories II and III alternatives is 577 mgd for the current member communities. The ratio of these flows is 0.6025 or 60.25 percent. This percentage is used in this Case Study to compute the portion of the project capital cost considered grant eligible.

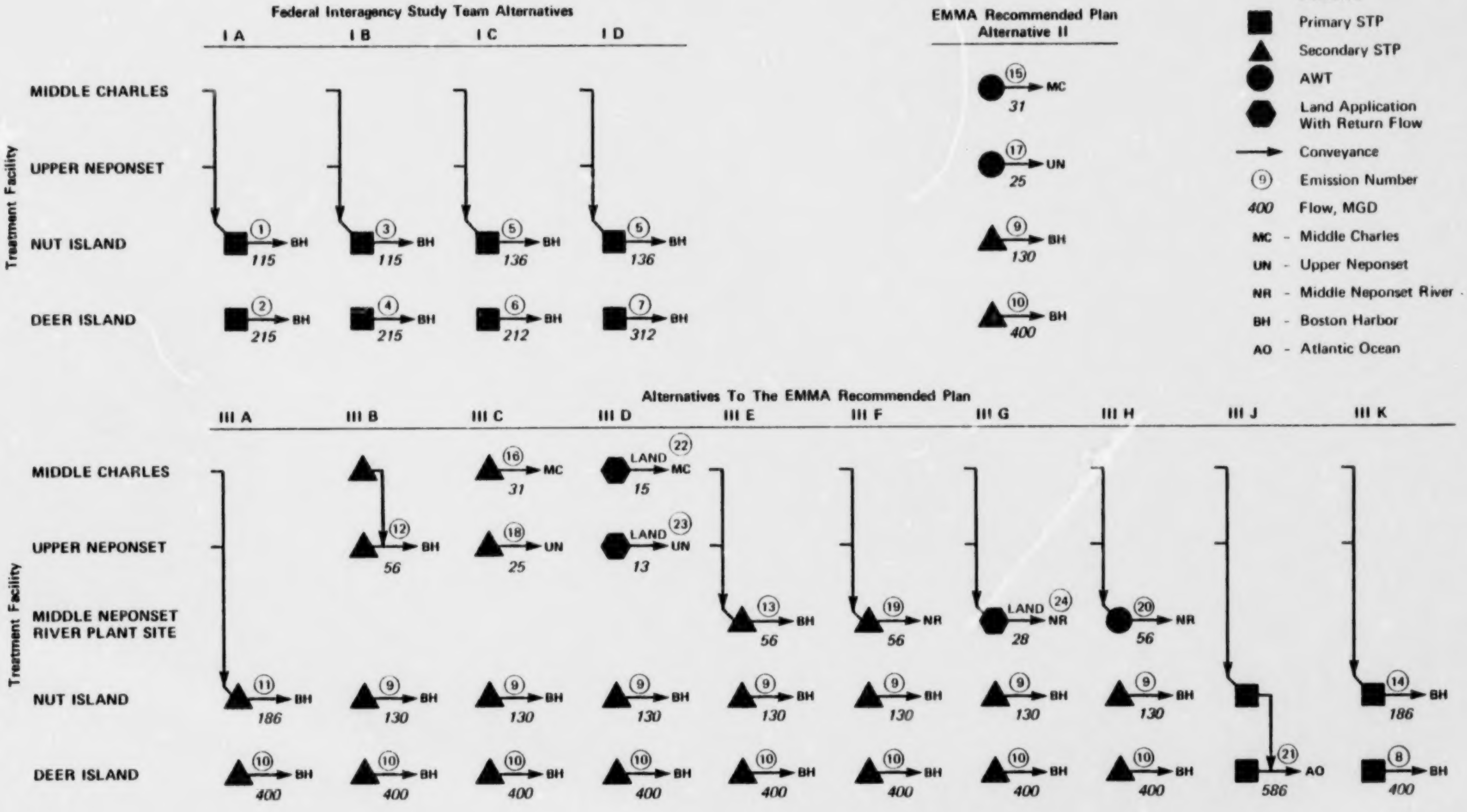
3. The data tabulated below list the costs of the EMMA Recommended Plan, Alternative IIA. The first column represents costs based on current funding policy. The second column represents revised costs under specific constraints as developed in this Case Study. The third column represents savings in the amount of grants (-), or the additional local share (+).

	Million Dollars		
	100 percent Eligibility	60.25 percent Eligibility	Difference
Project capital cost	$855.4	$855.4	
Eligible capital cost	855.4	515.4	
Ineligible capital cost	0	340.0	
Federal grant (75% of eligible cost)	641.6	386.6	-$255
State grant (15% of eligible cost)	128.3	77.3	- 51
Local share capital cost (10% of eligible cost plus 100% of ineligible cost)	85.5	391.5	+ 306
Local share annual O&M (100% of annual O&M)	25.6	25.6	

This Case Study indicates that appropriate facilities planning can reduce the scope of new wastewater projects. To optimize planning efficiency, Federal guidelines are needed.

Review and Comments

Draft Reports of this case study were distributed to staff and officials of various agencies that are involved with facilities planning, and to other interested parties. A series of meetings was held in Boston and a public hearing was conducted September 27, 1978. Written comments were received from twenty parties. All comments on the draft report were considered and the report has been modified and amplified as appropriate. It is emphasized that this case study stops as of the end of 1976.


Federal Interagency Study Team Alternatives
I A
I B
I C
I D
EMMA Recommended Plan Alternative II
LEGEND
Primary STP
Secondary STP
AWT
Land Application With Return Flow
Conveyance
⑨ Emission Number
400 Flow, MGD
MC - Middle Charles
UN - Upper Neponset
NR - Middle Neponset River
BH - Boston Harbor
AO - Atlantic Ocean
Treatment Facility
MIDDLE CHARLES
UPPER NEPONSET
NUT ISLAND
DEER ISLAND
① BH 115
③ BH 115
⑤ BH 136
⑤ BH 136
② BH 215
④ BH 215
⑥ BH 212
⑦ BH 312
⑮ MC 31
⑰ UN 25
⑨ BH 130
⑩ BH 400
Alternatives To The EMMA Recommended Plan
III A
III B
III C
III D
III E
III F
III G
III H
III J
III K
Treatment Facility
MIDDLE CHARLES
UPPER NEPONSET
MIDDLE NEPONSET RIVER PLANT SITE
NUT ISLAND
DEER ISLAND
⑯ MC 31
LAND ㉒ MC 15
⑫ BH 56
⑱ UN 25
LAND ㉓ UN 13
⑬ BH 56
⑲ NR 56
LAND ㉔ NR 28
⑳ NR 56
⑪ BH 186
⑨ BH 130
⑭ BH 186
⑩ BH 400
㉑ AO 586
⑧ BH 400

NOTE: For population served and influent loads, see Table 10-2
For character of emissions, see Table 10-3
For quantities of sludge produced, see Table 10-4.

NSF Boston Case Study, Phase II Evaluation

SUMMARY OF ALTERNATIVES

Kennedy Engineers, Inc. 1977

Figure **S**

CONTENTS

Introduction, Summary and Chapter 1

HISTORICAL DEVELOPMENT OF BOSTON AREA WASTEWATER FACILITIES

Section	Title	Page
	Introduction	i
	Figure 1, Study Area	ix
	Summary	s
A.	CHRONOLOGY UP TO THE 1972 PASSAGE OF PL 92-500	1.1
B.	CHRONOLOGY FROM 1972 TO 1976	1.36
C.	EXISTING WASTEWATER FACILITIES	1.51
	1. North Coastal Drainage Basin	1.61
	2. Ipswich River Drainage Basin	1.62
	3. SuAsCo Drainage Basin	1.63
	4. Mystic River Drainage Basin	1.63
	5. Charles River Drainage Basin	1.64
	6. Boston Harbor Region	1.65
	7. Neponset River Drainage Basin	1.68
	8. Weymouth River Drainage Basin	1.68
	9. South Coastal Drainage Basin	1.69
D.	EXISTING TYPES OF WASTE LOADINGS	1.69
	1. Untreated Sewage	1.69
	2. Treated Effluents	1.70
	3. Combined Sewer Overflows	1.72
E.	SUMMARY OF CHAPTER 1	1.73
	REFERENCES	1.75
Figure 1-1	Drainage Basins	1.52
Figure 1-2	Areawide Waste Treatment Management Area	1.53
Table 1-1	Study Area Communities By Drainage Basin	1.54
Table 1-2	Municipal Plants and Major Discharges	1.56
Table 1-3	Classified Municipal Facilities	1.59

Chapter 1

HISTORICAL DEVELOPMENT OF BOSTON AREA WASTEWATER FACILITIES

This chapter presents chronologically some highlights in the historical development of wastewater facilities in the Study Area as recorded in the literature. Key actions which have influenced water pollution in the Greater Boston Area both before and after the passage of PL 92-500 are also noted.

The chapter includes a listing of existing wastewater treatment facilities and an appraisal of the current situation in the drainage basins and the types of waste loadings in the study area.

A. CHRONOLOGY UP TO THE 1972 PASSAGE OF PL 92-500

Year 1630

Water has had a profound effect upon the lives of Bostonians since before the founding of this country. In the year 1630 inadequate water supplies, together with fevers and scurvy, were instrumental in causing a band of Puritans to abandon their first settlement in Charles Town. They crossed the Charles River to the Shawmut Peninsula (later to be named Boston) where a source of high quality drinking water was located. Here the Massachusetts Bay Colony was settled as a model community. The peninsula contained only 783 acres and actually was almost an island connected only to Roxbury by a very narrow neck of land. Boston quickly became an important shipbuilding center and fishing port. (By 1717 Boston was the largest English town in America). Because of epidemics of smallpox, typhus, typhoid, yellow fever, malaria, cholera and dysentery, together with numerous fires and war, rapid decreases in population occurred during the first 150 years, Reference 1.1.

1639

Mill Creek, or as it has later been called, "Mother Brook," in the Town of Dedham was dug by the English settlers as the source of water power for corn mills, according to "Historical Sketch of Mother Brook," by Erasmus Worthington, 1900. It resulted in the diversion of a portion of the Charles River into the Neponset River and is considered to be first inter-basin transfer of water in this country, Reference 1.2. (One-third of the flow of the Charles River is still diverted through Mother Brook today.)

1652

The earliest recorded public water supply system in Colonial America is credited to the City of Boston in 1652, when the General Court of the Colony established a waterworks company to build a conduit and reservoir for domestic use and extinguishing fires, Reference 1.3.

Late 1600's

In the late 1600's, private citizens of Boston began installing sewers at their own discretion to drain stormwater and water from cellars away from their properties, Reference 1.4.

1701

The population of Boston was approximately 8,000 people. Uncoordinated digging of streets for laying or repair of sewers was becoming a nuisance.

1709

Responding to the nuisances created by indiscriminate street excavation for sewer work, the Massachusetts General Court (Legislature) established sewer rules that regulated construction, ownership and maintenance of all common sewers and drains. (Private citizens conformed to the 1709 sewer regulations for the next 114 years, which required privies to be at least 40 feet from any street, shop or well, and are reported to have achieved sanitation standards unmatched anywhere.) Sewers constructed under the 1709 regulations were for draining cellars and land only, and toilet wastes were specifically excluded. Life expectancy was 35 years.

1776

Decimated by waterborne diseases, the resident population of Boston was only 2,700.

1788

The Commonwealth of Massachusetts joined the Federal Union.

1796

Governor Samuel Adams approved an act providing for a conduit from Jamaica Pond (Roxbury) to Boston. Most water was available only from private companies chartered from the State government, Reference 1.6.

1814

The introduction in Waltham of the first power loom launched the industrial revolution in this country. Textiles and clothing became major economic activities.

1823

The City of Boston obtained its charter and assumed control of all existing privately owned sewers and the construction and maintenance of new sewers. Fecal matter was still prohibited from sewers.

Also in the 1820's, the Fens Pond area, a tidal estuary, was known as the Full Basin. Stony Brook, which flowed into the Full Basin, was an open channel that contained direct sewer connections.

1833

Connection to the sewer system for discharge of fecal matter was allowed for the first time by the City of Boston, subject to approval by the Mayor and Alderman. This provision marked the start of Boston's combined sewer system.

1834

Discharge of roof drainage to sewers was allowed without fee or permit in order to aid in flushing debris out of the sewer system.

Mid-1800's

Construction of many miles of combined sewers produced increased pollution of Boston Harbor by discharges of mixed stormwater and untreated sewage. During the same period, a program of extensive filling of tidal areas relocated the shoreline of Boston Harbor. Back Bay filling from the Public Garden to Kenmore Square took from 1858 to 1888. Sewers were extended at relatively flat gradients and were subject to tidal action for many hours each day. This situation resulted in the accumulation of sludge and debris within sewers and on tidal flats.

A jail and house for paupers was built on Deer Island.

1850

Lemuel Shattuck of Boston completed the "Report of the Sanitary Commission of Massachusetts," which increased awareness of public health concepts which led, years later, to the creation of the Massachusetts State Board of Health, Reference 1.7.

1868

The Massachusetts State Board of Health, the first such in the country, was established, largely due to unsanitary conditions in the Boston area.

1870

Boston physicians declared the need for a better sewerage system.

1874

The Boston Board of Health urged major improvement of the sewer system to correct health problems.

The germ theory, advanced by Louis Pasteur, began to win acceptance.

1875

In March, the Boston City Council authorized the Mayor to appoint a special commission of two civil engineers and a sanitarian to study the existing sewerage system, and to recommend a plan for needed improvements and future requirements of the City.

In December of the same year, the special commission reported its findings and recommendations. Cited among the deficiencies in the then existing sewerage system were the backup of sewage into houses during high tides, sludge deposits in the sewers, and nuisance and odor problems created by sewage decomposing in Boston Harbor because tides did not provide adequate flushing.

The commission recommended a main drainage system north of the Charles River discharging to Shirley Gut but near Deer Island and another main drainage system south of the Charles discharging to Boston Harbor near Nut Island. There was opposition to the northern drainage system, and the City Council only adopted the commission's recommendation for a drainage system south of the Charles River.

1876

An expansion of Boston's water system was made based on recognition that an allowance of more than 30 gallons per capita per day was wasteful.

The Massachusetts Legislature passed Chapter 136 of the Acts of 1876, entitled "An Act to Empower the City of Boston to Lay, Finance, and Maintain a Main Sewer Discharging at Moon Island in Boston Harbor and for Other Purposes." Life expectancy increased to 40 years.

1877

Construction of the Boston Main Drainage System began, and for the first time the City of Boston required that all sewage be discharged to the City sewers.

1878

The first recording rain gauge was established near Boston at Chestnut Hill.

1881

Frederick Law Olmstead reported to the Boston Board of Park Commissioners that abatement of nuisances was his primary aim in planning parks for Boston.

The Back Bay Fens were described as:

> "a pestilential swamp into which Muddy River and Stony Creek emptied the drainage of thousands of acres of suburban Boston. The Fens oozed in turn into the Charles River tidal basin. Besides being chronic menaces to health, the Fen's sluggish watercourses backed up...."

He presented a grand concept for a system of urban and suburban parks which ultimately included the foul flow channels to carry drainage to the Charles River, Reference 1.8.

1884

Construction of the Boston Main Drainage System was completed. The system included about 25 miles of main and intercepting sewers, a pump station at Calf Pasture, an outfall sewer to Moon Island, and several holding basins on the Island with a total capacity of 50 million gallons. Raw sewage from Moon Island was to be released to Boston Harbor during ebb tide. This system was designed to collect dry weather flows of sewage plus a small amount of stormwater from the City of Boston. A primary function of the new system was to intercept dry weather raw sewage discharges to Boston Harbor that previously had been locally discharged. The 1884 Boston Main Drainage System project made no attempt to collect wet weather overflows, nor to serve areas outside of Boston proper.

1885

The first engineering report, "Main Drainage Works of the City of Boston," by E. C. Clarke was published, Reference 1.9.

1886

The American era of sewage treatment research began with the establishment of the Lawrence Experiment Station of the Massachusetts State Board of Health.

1889

The Massachusetts Legislature passed Chapter 439 of the Acts of 1889 which created the (North) Metropolitan Sewerage District for the cities and towns north of the Charles River, including East Boston and Charlestown. The same legislation created the Charles River Valley Sewerage System to serve Brighton, portions of the Back Bay area, and the towns west of Boston bordering the Charles. The Charles River Valley Sewerage system was connected to the Boston Main Drainge System at Gainsborough Street.

1889-1901

The Metropolitan Sewerage Commission administered the Metropolitan Sewerage District, the first legally constituted metropolitan district in the United States.

1890

The Commonwealth of Massachusetts was considered to have, in that year, the only State Health Department in the country effective in protection of water supplies, with due consideration given to stream pollution, according to Harrison P. Eddy, Reference 1.10.

1894

The North Metropolitan Sewerage System was completed. That system collected sewage from north of the Charles River and pumped it to Deer

Island where it passed a coarse screen and discharged continuously into Boston Harbor at a depth of 40 to 60 feet. (The original East Boston Steam Pumping Station is still an operational part of this system today.)

1895

Recognizing the need for a metropolitan water supply, the Metropolitan Water District was created and work began on the Wachusett Reservoir and Aqueduct.

Investigations of industrial waste treatment by the Massachusetts State Board of Health began in 1895 at the Lawrence Experiment Station.

1899

The Massachusetts Legislature passed Chapter 424 of the Acts of 1899 which established the South Metropolitan Sewerage District to serve portions of the Charles River Valley, the Neponset River Valley, and adjacent areas south of the Boston Main Drainage System.

Metropolitan Sewerage Commissioners prepare their first report on main drainage works. The sewers are reported as designed to remove a quantity of stormwater equivalent to 1/4-inch of rain per day. It is also reported that daily leakage of groundwater amounts to 80,000 gallons per mile of sewer, equivalent to 100 gallons per inhabitant per day, Reference 1.11.

1900 to 1930

Pollution of Boston Harbor and the Charles River Basin was investigated in numerous reports by direction of the Massachusetts Legislature: in 1900 by the State Board of Health upon the discharge of sewage to Boston Harbor; in 1903 by the Committee on the Charles River Dam; in 1915 by a Joint Board, House Document 1635; in 1917 by the Metropolitan Water and Sewerage Board; State Commissioner of Health and the Boston Commissioner of Public Works House Document 1215; and in 1929 and 1930 by a Special Commission of the Senate, Senate Document 56, Reference 1.12, 1.13.

1901-1919

The Metropolitan Water and Sewerage Board administered the water and sewerage districts of the metropolitan area, after abolishment of the Metropolitan Sewerage Commission by the Massachusetts Legislature.

1904

The South Metropolitan Sewerage System was completed. That system collected sewage from parts of the Charles River Valley, the Neponset River Valley and adjacent areas south of the Boston Main Drainage System and conveyed it to Nut Island, where it was coarse-screened and discharged continuously into Boston Harbor through three outfalls 27 feet below the water.

The Charles River Valley Sewerage System was incorporated into the new South Metropolitan Sewerage District.

1905

The Ward Street Pumping Station was completed and used to lift flow from the Charles River Valley to the South Metropolitan High Level Sewer (until 1967 when a tunnel was built to Deer Island).

1906

The taking of shellfish from some areas within Boston Harbor was prohibited because of polluted water.

1907

The Massachusetts Legislature passed Chapter 485 of the Acts of 1907, which established a program of separation of combined sewers in order to reduce the frequent pollution caused throughout the year by combined sewer discharges. That legislation directed the City of Boston to spend 0.05 percent of its taxable valuation on sewer separation.

1910

The Charles River Dam at Leverett Street was completed by the Commonwealth of Massachusetts to prevent tidal flooding of lowland sewers and drains along the lower reach of the Charles River, to create a constant level recreational pool, and to cover unsightly tidal flats. This dam with lock, located one mile above the mouth of the Charles, maintains a level of 2.4 feet above mean sea level for about 8-1/2 miles above the dam.

Elimination of tidal flooding made the Back Bay Fens Pond a freshwater body, receiving combined wastewater overflows from the Stony Brook Sewer System, some flow from the Muddy River, and local drainage.

1912

First laboratory experiments with activated sludge treatment of sewage began at Lawrence Experiment Station in Massachusetts.

1914

The Union Park Street pumping station in Boston was constructed to reduce flooding in low-lying areas of the South End. This station was designed by E. S. Dorr, and was the largest automatic pumping station in the country.

Life expectancy is reported to have increased to 50 years.

1917

The first use of multiple outlets on a sewage outfall occurred in the Deer Island outfall extension of the North Metropolitan Sewerage District.

1919

The Metropolitan District Commission was created to assume the powers, duties and responsibilities of the Metropolitan Parks Commission and the Metropolitan Water and Sewerage Board.

1930

The report (attached to Senate Document 56) of the Board of Engineers on a two-year study of Boston Harbor states:

> "The quantity of water entering and leaving Boston Harbor with mean tides is 76,086 million gallons,
>
> The quantity of water remaining at mean low water is 108,305 million gallons, and
>
> The total water in the harbor at mean high tide is 184,391 million gallons."

The report considered relocating the 175 sewer outlets in the Harbor to a remote point at sea via 14 miles of tunnel, or activated sludge processing plants and incinerators on Peddocks Island and Deer Island. Recommendations included immediate screening and studies to determine the condition of the waters of the harbor at frequent intervals to observe changes taking place.

1933

The Massachusetts legislature passed a law requiring the purification of oysters taken from areas with polluted water prior to being sold to consumers. The State Department of Health was required to examine the tidal waters from which the shellfish were taken. If the waters were polluted and purification of the shellfish was necessary, the law allowed for the recovery of the cost of the required purification plant from each polluting community in proportion to their relative shares in causing the pollution, Reference 1.14.

The same year also marked the first publication by the U.S. Weather Bureau of a monthly tabulation showing precipitation that occurred for each hour of the month at recording rain gauges in the Boston area.

1936

A legislative investigation was conducted by a special commission consisting of the Massachusetts Commissioners of Public Works and Public Health, Commissioners of the Metropolitan District Commission, and the Boston Commissioners of Health and Public Works. In December, the "Report of the Special Commission on the Investigation of the Discharge of Sewage into Boston Harbor and its Tributaries" (House Document 1600) was completed. This study found nuisance conditions primarily in the vicinity of the main sewer system outlets in Boston Harbor off Deer, Nut, and Moon Islands, and at some combined sewer overflow outlets. Also cited was the fact that, under certain tide and wind conditions, objectionable floating matter, typical of sewage, floated into several of the area's bathing beaches. Pollution was also documented by studies of wood chips released from outfalls and extensive bacterial analyses of the waters and sediments of Boston Harbor, Reference 1.15.

House Document 1600 recommended the following major programs:

1. Separation of combined sewers in the Boston and MDC systems to prevent combined sewage overflows,
2. MDC to provide devices for measuring sewage entering the Metropolitan Sewerage System and to charge tributary cities and towns according to the amounts of sewage they contribute,
3. Construction of facilities necessary to prevent surface and stormwater from entering the Boston Main Drainage System and the North and South Metropolitan Sewerage Systems,
4. Closure of bathing beaches on the Boston Harbor waterfront and its tributaries allowed by appropriate Boards of Health,
5. Consideration of construction of facilities to treat sewage from the Boston Main Drainage System and the North and South Metropolitan Sewerage Districts before it is discharged to Boston Harbor, and consideration of relocating these outlets, "in the distant future if necessary," to a point near the Graves for disposal of treated sewage, and
6. Consideration of construction of primary sewage treatment plants on Deer, Nut, and Moon Islands, with possible addition of sludge incineration at these locations.

1939

On June 15, 1939, a report, entitled "Report of the Special Commission Investigating Systems of Sewerage and Sewage Disposal in the North and South Metropolitan Sewerage Districts and the City of Boston" (House Document 2465 of 1939), was completed with the aid of consulting engineers Harrison P. Eddy, Jr. and Samuel A. Greeley, Reference 1.16.

Those investigations in 1938 and 1939 found pollution of the Mystic and Charles Rivers from combined sewer overflows and recommended construction of various storm overflow relief conduits. It was also recommended that the North Metropolitan relief sewer be extended from East Boston to Deer Island.

The consultants found bacterial pollution of the water of Boston Harbor and its beaches, and of the harbor sediments. These conditions were considered potentially dangerous to the public health to such an extent that construction, as soon as practical, of three sewage plants was recommended at Deer Island, Nut Island, and Moon Island, essentially as recommended in 1936. The treatment facilities recommended in the 1939 report consisted of bar racks, grit chambers, pre-aeration, pre-chlorination, sedimentation, post-chlorination, and discharge via existing outfalls. Sludge was to be stored and barged to open sea waters for disposal. Skimmings and scum would be incinerated. The three plants were to serve a 1955 total design population of approximately 2,050,000 people and a total average design sewage flow of 323 million gallons per day (mgd). The total construction cost of the three plants in 1940 was estimated to be $10,022,000. (Note that primary plants at Nut and Deer Islands were later built.)

1940

Weston and Edwards publish studies on sewage treatability, and recommended primary plants at Moon, Deer, and Nut Islands, and barges for hauling sludge to sea, Reference 1.17.

1941

In January, the consulting firms of Metcalf and Eddy, Inc. and Greeley and Hansen, Inc. jointly completed a preliminary engineering report for MDC on "Sewerage and Sewage Disposal Studies under Chapter 512, 1939, General Design Drawings and Final Report." This detailed report contained general design drawings for the proposed sewage treatment plant and pumping station at Nut Island, as well as the proposed overflow conduit along the South Bank of the Charles River and the North Metropolitan Relief Sewer, as were recommended by previous special commission reports, Reference 1.18.

1945

The Massachusetts Legislature passed Chapter 705 of the Acts of 1945 which authorized the following projects and a bond issue of $15,000,000 to finance this work:

1. Construction of a sewage treatment plant at Nut Island for the sewage from the South Metropolitan Sewerage District,
2. Extension of the North Metropolitan Relief Sewer to Deer Island including a pump station at East Boston,
3. Investigations, borings, designs, plans and specifications only, for a sewage treatment plant at Deer Island for the sewage from the North Metropolitan Sewerage District and,
4. Construction of pump stations, conduits and other works for relief from stormwater overflows along the Charles River and Alewife Brook.

1946

Quabbin Water Supply Reservoir, constructed in the early 1930's by the MDC in Central Massachusetts, is filled for the first time.

Two articles by Karl R. Kennison entitled "Disposal Plant to alleviate Boston Harbor Nuisance" and "Problems of Solids Disposal Solved" were published in June and July. They report that Boston Harbor receives over 250 mgd of raw sewage and that investigations conducted by the State Department of Public Health over the past 10 years show that a high degree of treatment is not necessary because of great dilution. The proposed Nut Island treatment works are described as having capacity for a population of 900,000 and average flow of 112 mgd, Reference 1.19.

1947

The Massachusetts Legislature authorized an additional $8,000,000 for the work begun under Chapter 705, Acts of 1945.

In March of the same year, Jack McKee presented a paper to the Boston Society of Civil Engineers, which provided new concepts regarding estimation of the loss of sanitary sewage during storm overflows. McKee's paper discussed techniques by which engineers can use probability studies of historical rainfall data to provide the optimum balance between combined sewer design economy, and abatement of pollution to protect shellfish beds and other uses of receiving waters. The Boston metropolitan area was used as a case study for that paper, Reference 1.20.

1948

Metcalf and Eddy, Engineers, completed a report for the Metropolitan District Commission entitled "Comprehensive Plan for the Relief of Storm Overflows into Charles River Basin and Extension of North Metropolitan Relief Sewer from East Boston to Deer Island." That report discussed and supported earlier engineering studies on the same subject.

In 1948 and again in 1949, Camp, Dresser and McKee submitted reports to the Joint Board "Relative to the Disposal of Sewage in the South Metropolitan Sewerage District" (House Documents 2151 and 2263, respectively). These reports recommended relief of the South Metropolitan High Level Sewer by diversion of the Charles River Valley system into the North Metropolitan Sewerage District system.

1949

The Massachusetts Legislature authorized an additional $25,000,000 under Chapter 606, Acts of 1949, for completing work previously authorized under Chapter 705 of 1945. The 1949 authorization included construction of the Deer Island sewage treatment plant, and a stormwater overflow conduit on the south side of the Charles River.

The Massachusetts Legislature passed Chapter 598 of the Acts of 1949 which authorized a $15,000,000 bond issue for the City of Boston to construct a sewage treatment plant at Calf Pasture and to reconstruct and alter the existing sewerage works at Calf Pasture and Moon Island. (That legislation was repealed by Chapter 645, Acts of 1951.)

1950

An engineering study was completed by C. A. Maguire and Associates for the Metropolitan District Commission (MDC) entitled "Report on the Comprehensive Sewage Plan of Sewage Disposal Needs and Alternate Plans, April 1950."

1951

An engineering study was completed by C. A. Maguire and Associates for the MDC, entitled "Report on a Proposed Plan of Sewerage and Sewage Disposal for the Boston Metropolitan Area," February 1951. The report recommended formation of a single sewerage district for joint disposal of sewage from the areas composed of the North Metropolitan Sewerage District expanded to include the Boston Main Drainage System and the Charles River Valley sewerage system of the South Metropolitan Sewerage District. Sewage from these three areas would be conveyed by means of deep rock tunnels to Deer Island for treatment.

This study apparently rejected the proposed construction of a separate sewage treatment plant for the City of Boston at Calf Pasture and resulted in the repeal of funding authorized for 1949 by adoption of Chapter 645 of the Acts of 1951.

The Massachusetts Legislature passed Chapter 645 of the Acts of 1951, which authorized an expenditure not to exceed $25,000,000 for the implementation of the recommendations made in the 1951 C. A. Maguire and Associates report on a joint disposal plan. The facilities authorized by Chapter 645 of 1951 include the following:

1. Construction of a tunnel between Columbia Circle and Deer Island with necessary expansion of the proposed Deer Island sewage treatment plant to treat this additional flow,
2. Construction of a tunnel between the Ward Street pumping station and Columbia Circle,

3. Construction of a relief sewer between the Boston University Bridge and Ward Street,
4. Construction of a relief sewer for the West Side and Stony Brook interceptors of the Boston Main Drainage District,
5. Construction of a Marginal Conduit pump station, and
6. Rehabilitation of tide gates and pump stations.

In addition, Chapter 645 of 1951 made the Boston Main Drainage District a part of the South Metropolitan Sewerage District.

1952

Construction was completed and the Nut Island Sewage Treatment Plant started operation to provide primary treatment for dry weather sewage flows from the South Metropolitan Sewerage District. The Nut Island plant became the first operative treatment facility in a pollution abatement program first approved in House Document 1600 in 1936. Digested sludge was discharged to Boston Harbor on the ebb tide via a submerged outfall. Chlorination was practiced from May to October during the major season for shellfish taking and public use of beaches.

The claimed special features of plant design according to the Annual Report of the MDC are:

"1. The first installation of dual fuel engines to furnish all power used throughout the plant. The engines, having a total of 3000 horsepower, operate equally well on either methane gas, which is a by-product of the digestion process, or on fuel oil.

2. 2 - 200 H. P. liquid rheostats for wound rotor motor speed control, effecting variable speed of main sewage pumps.

3. Multiple hearth incineration of sewage screening and grit and the scum formed in the digesters.

4. Pre-aeration of the raw sludge, to aid in grease removal and prevent a formation of objectionable sleek areas on the harbor waters, was another important "first."

5. The use of individual 36" and 42" comminutors for homogenization of sewage solids.

6. High-rate recirculation in primary digesters, with external heating for scum control and uniform digestion with an average detention rate of sixteen days.

7. Chlorinating facilities arranged for pre and post-chlorination.

8. Digested sludge line cleaner, used for annual cleaning of 4.2 miles long, 12" diameter submarine pipe line. Resembles a porcupine in appearance, and is nicknamed "The Go-Devil."

9. The first installation of the vertical torque flow solids pump for grit sump and grit channel dewatering.

10. Raw sludge line cleaner device, located in the Digester Building. Of special design and construction, this device maintains more than one-half mile of 6" diameter raw sludge line piping in a clean, workable condition.

11. Two 3 c.f. capacity pneumatic screenings ejectors, and one 25 c.f. grit and scum pneumatic ejector," Reference 1.21.

1957

A massive urban renewal program was launched in Boston. As an adjunct to the redevelopment activities, some of the old deteriorated and combined sewers were replaced with new sewers in construction projects administered by the Boston Redevelopment Agency and financed in part with HUD funds.

1959

The Massachusetts Legislature passed Chapter 612 of the Acts of 1959 by which the North and South Metropolitan Sewerage Districts, including the area served by the Boston Main Drainage system, were combined to become the present unified Metropolitan Sewerage District. This act also revised the basis for apportionment of construction and operating costs of the sewerage system of the Metropolitan District Commission by adopting the "demand-capacity" ratio method. In the "demand-capacity" ratio method, the flow-contributing town or city is charged in the ratio of its capacity demand (based on the number and size of its connections to the Metropolitan Trunk System) to the capacity available for it in the Metropolitan Trunk System. (This system is contrary to EPA revenue program requirements enacted later.)

Pollution due to overflows of mixed sewage and stormwater is extremely complex, involving enormous cost and requiring a tailor-made solution for each location according to Thomas R. Camp, in "Realistic Appraisals Must Be Made of Values of Uses of Receiving Waters," Reference 1.22.

1962

The Public Health Service 1962 "Inventory of Municipal Waste Treatment Facilities" shows fourteen plants (in the EMMA study area) which are considered to provide primary treatment or better. One is the Nut Island primary treatment plant of the South MSD with a reported average daily flow of 112 million gallons per day (MGD), which serves nineteen communities and part of the City of Boston. The other plants each have an average daily flow of around 1 MGD or less and serve all or a portion of Billerica, Concord, Franklin, Holbrook, Hudson, Ipswich, Marlborough, Marshfield, Maynard, Medfield, Milford, Millis, and Wayland. Also for the EMMA study area, the inventory lists thirty-five sewered communities which have virtually no treatment, although several are noted as having adequate deep sea outfalls, while forty-one communities are noted as unsewered.

The City of Boston's population of 697,197 was shown served as follows:

> 61,805 persons served by North MSD (at Deer Island) with no treatment except hand-cleaned bar racks, 280,045 persons served by South MSD (at Nut Island) with primary treatment, and 355,400 persons served by the Boston Main Drainage System (presumably at Moon Island) with no treatment.

The sewer systems of Lynn, Marshfield, and Medway are shown in 1962 as entirely of the combined stormwater/sanitary sewage type, while the sewer systems of Arlington, Boston, Brookline, Cambridge, Chelsea, Everett, Milford, Milton, and Somerville are shown as partially of the combined type and partially of the separate type, Reference 1.23.

1963

The Metropolitan Area Planning Council (MAPC) was created by the Massachusetts Legislature (Chapter 668, Acts of 1963) to plan and implement solutions to problems on a regional scale. Original membership was 47 cities and towns, (since grown to 101), Reference 1.24.

1964

C. A. Maguire and Associates completed a report for the Boston Redevelopment Authority. This report, entitled "Preliminary Studies of Existing Utility Systems," described investigations of parts of Boston's existing sewerage system in relation to urban renewal projects, and includes the results of sewer inspections and gagings conducted in Boston's South End.

1965

In August, a paper published by Clair N. Sawyer commented on aquatic growths (sea lettuce) in Winthrop Harbor that had resulted in odor nuisances during the 1950's and early 1960's. Raw sludge discharges of approximately 100 million gallons per day from Deer Island was cited as the source of nutrients causing the marine growths. The paper concluded that primary treatment with discharge of sludge at Deer Island would not reduce the nutrient content discharged, but would only change the form, Reference 1.25.

1966

The General Court passed the "Massachusetts Clean Waters Act" (Chapter 685 of the Acts of 1966) creating the Division of Water Pollution Control, Water Resources Commission, Commonwealth of Massachusetts to enhance the quality and value of the water resource, and to establish a program for the prevention, control and abatement of water pollution. The new Division was given comprehensive responsibilities, including the establishment of Water Quality Standards and the classification of all waters of the Commonwealth.

1967

In May, the "Inventory of Water and Sewer Facilities" for MAPC and DCD was completed by Camp Dresser & McKee, Reference 1.26.

Also, in May, the first diversion of flows from the Boston Main Drainage System to the MSD system was effected at Camden Street. These flows enter the MSD Boston Main Drainage tunnel in Roxbury through the Ward Street Headworks and go to Deer Island.

In June of 1967, the waters of the Commonwealth of Massachusetts were classified pursuant to the 1966 Act, based on Water Quality Standards adopted by the Massachusetts Division of Water Pollution Control (DWPC) on March 3, 1967.

In July of the same year, the Metropolitan Area Planning Council (MAPC) was designated by the U.S. Office of Management and Budget as the areawide review agency (Metropolitan Clearinghouse) for federal aid programs as authorized by what is now known as Circular A-95.

In September of 1967, Camp, Dresser and McKee (CDM) completed a 1-1/2-year study on "Improvements to the Boston Main Drainage System" for the City of Boston. This investigation found that, although projects had been completed or were under construction for conveyance, treatment and disposal of dry-weather sewage flows plus a small increment of stormwater, little progress had been made to eliminate the significant pollution of Boston Harbor and its tributaries due to combined sewer overflows. Water quality sampling for bacterial contamination at recreational and shellfish areas indicated that significant hazards to health were presented by discharges of mixed sewage and stormwater (which occur nearly every time it rains, or about 5 or 6 times each month, as reported by Dr. J. E. McKee in 1947). On one occasion during the sampling program in October 1966, masses of grease balls and other sewage debris were found on the South Boston beaches, Reference 1.4.

The two-volume report states that no projects had been constructed or planned at that time that would significantly improve water quality in the

Boston area and recommended a "deep tunnel plan" for elimination of combined sewer overflows. The deep tunnel plan proposed the construction of five major deep rock tunnels under the City of Boston at a depth of about 300 feet which would collect overflows from existing combined sewers via vertical shafts and transmission tunnels. These main tunnels would store and conduct the overflows to a central chamber at Columbus Park. A single main storage tunnel would extend beneath Boston Harbor from Columbus Park to Deer Island. At Deer Island, the overflow water would be screened, chlorinated and pumped through a long ocean outfall to a disposal point in 100-feet deep waters of Massachusetts Bay beyond the Graves. To be completely effective in eliminating pollution from combined sewer overflows, the combined sewer areas of Brookline, Cambridge, Chelsea and Somerville were included with the City of Boston in the area to be served by the deep tunnel system.

The estimated construction cost of the deep tunnel plan for elimination of combined sewer overflows from a 15-year frequency design rainfall was approximately $430,000,000 (ENR 1100). The 1967 report also proposed a two-phase construction program for improvements to the existing City of Boston Sewerage Systems to correct structural and capacity deficiencies in the City's existing sewer system. The "initial construction program" had an estimated construction cost of $37,850,000 (ENR 1100), and the second priority "future construction program" had an estimated construction cost of $118,900,000 (ENR 1100). The deep tunnel plan was approved by the City of Boston and the Commonwealth of Massachusetts in 1967 and 1968, but was not funded.

In 1967, Camp, Dresser and McKee completed another report entitled "Inventory of Water and Sewer Facilities," which was prepared for MAPC & DCD with a federal grant from the Urban Renewal Administration of HUD. This report found 41 communities (total 1965 population of 312,432 persons) of MAPC's 110* communities did not have public sewerage systems. Of the 391 mgd of dry weather sewage contributed to public sewers in the MAPC communities, 66 percent was discharged without even primary treatment in 1965. With the completion of the Deer Island primary treatment plant, the percentage of sewage discharged untreated to surface waters was projected to be 11 percent of the dry weather flows.

On September 6, 1967, the New England River Basins Commission (NERBC) was created by executive order 11371 pursuant to the 1962 Water Resources Planning Act. NERBC is a federal agency established to function as the principal agency for coordination of federal, state, and local water development plans and to prepare a comprehensive water quality management plan for the Boston Harbor Drainage Area.

1968

In 1971 the EPA published the "1968 Inventory of Municipal Waste Facilities" which is similar to the 1962 PHS Inventory. A comparison of the data in the 1968 Inventory (for the EMMA study area) indicates, in the six years which elapsed since the 1962 Inventory, that:

> New treatment plants had been built by the Towns of Scituate and Westborough, and

---

*The area of that inventory was larger than the 101 communities now in the MAPC.

former combined sewers had been separated
in Arlington, Marshfield, Milford, and Milton.

The 1968 Inventory also shows that:

The South MSD provides 122 mgd "Secondary
Treatment" (sic) for 20 communities and
part of the City of Boston (at Nut Island),

The North MSD has a primary plant under
construction (at Deer Island), and

Over one-half of the population of the City of
Boston served by the Boston Main Drainage
System still has no treatment facilities.

Pollution abatement needs are given in the 1968 Inventory for each sewered community. The following are the only Cities, Towns or Districts listed as "No Project Needed" (according to 1968 requirements) which are in the EMMA study area comprised of 109 Cities and Towns and three sewerage Districts:

Billerica,
Concord,
Hudson,
Marlborough,
South M.S.D.,
Milford, and
Scituate (Reference 1.27)

The Deer Island sewage treatment plant began operation in June to provide primary treatment of dry weather flows from the North Metropolitan Sewerage District. Treatment facilities included screening and grit removal (at all headworks), pre-chlorination, pre-aeration, primary sedimentation, post-chlorination, and effluent disposal via submerged outfalls. Digested sludge was discharged via submerged outfall after dilution with effluent.

Special innovative features of the Deer Island Plant were reported as:

> 3 headworks located four to seven miles away, connected by deep rock tunnels 300-feet below Boston Harbor,
>
> Raw sewage pumping by nine 100 mgd pumps 100-feet underground driven by 12-cylinder, two-cycle, 2,125 horsepower radial dual fuel engines,
>
> Use of salt water or effluent for engine cooling, chlorine injector water and other plant uses, and
>
> Ocean disposal of digested sludge.

Also in 1968, the new Charles River Dam project was authorized to control flooding, improve navigation, and aid highway transportation. (Construction of the new Charles River Dam, located about one-half mile below the old dam, began in February 1973, and is scheduled for completion by the end of 1977.)

The first "Conference in the Matter of Pollution of Navigable Waters of Boston Harbor and Its Tributaries" was held on May 20, 1968.

1969

The National Environmental Policy Act of 1969 (NEPA) became Federal law. NEPA, as implemented by Executive Order 11514 of March 5, 1970, and the August 1, 1973 Guidelines of the Council on Environmental Quality (CEQ), requires that all Federal agencies prepare environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment.

The second session of the "Conference in the Matter of Pollution of the Navigable Waters of Boston Harbor and Its Tributaries" was held on April 30, 1969. The conferees of the second session recommended, among other things, that additional chlorination capacity be provided at the Deer and Nut Island sewage treatment plants and that tide gates in Boston be repaired. The Second Enforcement Conference also recommended that a consulting firm be retained to evaluate the hydrographic conditions of Boston Harbor, particularly the dispersion characteristics and mixing zones affecting effluent and sludge disposal from Deer Island and Nut Island.

In July 1969, Camp, Dresser and McKee updated their 1967 Inventory of Water and Sewer Facilities in the MAPC area. This study found that the respective capacities of the MDC water and sewerage systems would be exceeded by 1980 and that many neighoring communities outside MDC would also be in need of additional water and sewerage facilities. In 1969, the safe yield of the MDC's water system was exceeded, and a similar situation was found to exist, or was projected to exist in the future in most other communities in the MAPC area, Reference 1.28.

1970

U.S. Government Reorganization Plan No. 3 transferred fifteen governmental units with their functions and legal authority into the newly created U.S. Environmental Protection Agency (EPA) within the Executive Branch.

Cottage Farm Detention and Chlorination Station, located just above the Boston University Bridge adjacent to the Charles River, was completed. The project received a $1,000,000 Federal demonstration grant. The installation is designed to collect, screen, chlorinate and detain combined sewer overflows at the junction of the North and South Charles sewerage systems.

On August 26, 1970, the Board of Certification of Operators of Wastewater Treatment Facilities was established by the General Court by enactment of

Chapter 13, Section 66A of the Acts of 1970. The appointed Board is to "insure the proper management, operation and maintenance of waste water systems" in the Commonwealth. The Board has enacted Rules and Regulations which provide for seven classifications of facilities and seven corresponding certificated grades of operators.

Also, in August the Massachusetts DWPC published a "Boston Harbor Pollution Survey - 1968" which contained an inventory of wastewater discharges and water quality data collected during 1968. The authors, Sabin M. Lord, Robert C. McAnespie, David E. Costello and William R. Jobin, catalogued 405 sources of pollution discharging into Boston Harbor and estuaries of its tributaries, (Reference 1.29.

The October 1970 publication of the New England River Basins Commission (NERBC) states "NERBC is encouraged that progress is being made toward improving the water quality of the Harbor," Reference 1.30.

1971

In October, the New England River Basins Commission Boston Harbor Coordinating Group released a study entitled, "Interim Report on Combined Sewer Overflows in Boston Harbor." The study was prepared by EPA Region I in cooperation with the City of Boston, Massachusetts DWPC, MAPC, MDC, and NERBC and in conjunction with the third session of the "Conference in the Matter of Pollution of the Navigable Waters of Boston Harbor and Its Tributaries." The findings of the interim report indicated that combined sewer overflows are a major deterrent to achieving water quality goals in Boston Harbor and that raw sewage can still enter receiving waters during dry weather periods at low tides.

The study cites the fact that in 1969, 24 percent of the measured flow at the Deer Island treatment plant was from salt water inflow associated with unrepaired malfunctioning tide gates, Reference 1.31.

On October 1, 1971, the Massachusetts DWPC and MDC signed a "Memorandum of Agreement" concerning sludge disposal from Deer and Nut Islands in Boston Harbor. The hydrographic study of Boston Harbor, commissioned at the Second Enforcement Conference in 1969, had concluded that 15 to 20 percent of the sewage sludge solids discharged on ebb tide would deposit in the harbor west of Deer Island. The Memorandum of Agreement stated that MDC would study alternative sludge disposal methods for the sludge from Deer and Nut Islands and submit a preliminary report by April 1, 1972, and an engineering report by April 1, 1973.

The Third Enforcement Conference, which convened on October 27, 1971, concluded that present sludge disposal practices at Deer and Nut Islands were not suitable to meet the "SB" water quality standards of the harbor receiving waters. The Third Conference also required MDC to prepare a preliminary sludge study by April 1, 1972, and to propose an implementation schedule by July 1, 1972, Reference 1.32.

In June 1971, a report by the Thompson and Lichtner Company found that the six primary sedimentation tanks on Nut Island had settled to some degree. The most northerly tank has settled the most, with an overall average settlement of 12 inches and a maximum settlement of 24 inches. This report found that the settling of these tanks had reduced effective capacity and impaired the ability of these tanks to remove sludge and scum.

Also in 1971, Hydroscience completed the "Final Report on Development of Water Quality Model of Boston Harbor" for the Commonwealth of Massachusetts Water Resources Commission. The Final Report contains information on dissolved oxygen (DO), phytoplankton and chlorophyll concentrations in Boston Harbor. In 1970 and 1971, DO values below 3 mg/l were found in Boston's Inner Harbor, but the DO levels in other parts of the Harbor had generally improved since 1967 monitoring. The findings of this study with respect to sludge disposal influenced the signing of the Memorandum of Agreement between MDC and DWPC, as discussed above.

1972

In April 1972, the Boston Harbor Pollution Task Force (formed as a result both the 1971 Memorandum of Agreement and the Third Enforcement Conference) completed "A Study of Alternative Methods of Sludge Disposal for the Deer Island and Nut Island Sewage Treatment Plants." That investigation was a preliminary study of various sludge disposal alternatives and recommended that a detailed engineering report be prepared to evaluate three specific methods of sludge management: 1) application to land; 2) dewatering and incineration; and 3) wet oxidation.

In July 1972, the MDC, DWPC, and EPA signed the so-called "Three Party Agreement." The Three Party Agreement mandated, first, the EMMA Study for the long-range management of wastewater in Eastern Massachusetts; and second, the final steps in the preliminary engineering investigations of sludge management plans for MDC.

On July 12, 1972, Governor Sargent signed a law to provide money for preventing combined sewer overflows adjacent to the bathing beaches of Dorchester Bay and South Boston, the so-called Old Harbor Pollution Control Program. On the assumption that the above project would be built, Camp, Dresser and McKee, in a November 1972 report to the DWPC, recommended the construction of a marginal conduit to collect combined sewer overflows along Tenean and Malibu beaches. The conduit would convey the overflows to a pumping station proposed to be built as part of the Old Harbor Pollution Control Program (or to the Deep Tunnel System if it were constructed). The recommended program was estimated to cost $40.6 million @ ENR 1800. Until the facilities are constructed, CDM recommended five interim chlorination stations for disinfecting overflows near Tenean and Malibu beaches, Reference 1.33.

In the spring of 1972, the Congress requested the Corps of Engineers to undertake a joint study with the Commonwealth of Massachusetts to recommend improvements and alternatives for wastewater management for the Boston Metropolitan Area.

A Report to the Massachusetts Divison of Water Pollution Control, dated August 7, on combined sewer overflows to the Charles River Basin, recommends monitoring of overflows, and "the relationship between the operation of the Deer Island Sewage Treatment Plant, the Ward Street Headworks and overflows to or from the B.U. (Cottage Farm) Detention Facility should be more closely examined. Appropriate operating policies at the first two facilities may greatly reduce the pollution potential of the latter, Reference 1.34.
Also in 1972, MAPC adopted a "Boston Harbor Islands Comprehensive Plan."

In October 1972, Camp, Dresser and McKee reported to MAPC on "Alternative Regional Solutions for Sewerage Systems for the Boston Metropolitan Area." That study included fifteen plans (A-O) with two or three treatment alternatives in all eight MAPC drainage basins plus 2 alternatives for MDC Deer and Nut Island systems improvements, Reference 1.35.

Prior to passage of the Federal Water Pollution Control Act Amendments of 1972, sewerage system planning reports for several communities outside the MSD had also been completed, for example: "Report on Sewerage and Sewage Disposal, Town of Nahant, Massachusetts" by Camp, Dresser and McKee (1968); "Report on Proposed Sewerage System and Sewage Treatment Facilities, Hull, Massachusetts" by Whitman and Howard, Inc. (1969); "Wastewater Collection and Disposal Facilities for the Town of North Reading, Massachusetts" by C. A. Maguire and Assoc., (1970); "Report to Old Colony Planning Council, Brockton, Massachusetts, on Phase One (1969), Phase Two (1970), and Phase Three (1971) of Water and Sewerage Study" by Metcalf and Eddy, Inc.; and "Report to Department of Public Works on Addition and Improvements to Sewerage System, Lynn, Massachusetts" by Metcalf and Eddy, Inc. (1972).

During 1972, Congress enacted many bills which provided EPA specific authority for controlling pollution. These legislative measures included the Federal Water Pollution Control Act Amendments of October 18, the Federal Environmental Pesticide Control Act, the Noise Control Act, and the Marine Protection, Research, and Sanctuaries Act, all in 1972. Congress had passed previously the Clean Air Act Amendments, the Resource Recovery Act, and the

Uniform Relocation Assistance and Real Property Acquisition Policies Act in 1970. Congress was later to pass such acts as the Solid Waste Disposal Act (1973), Flood Disaster Protection Act (1973), the Endangered Species Act (1973), the Archaeological and Historic Preservation Act (1974), and the Safe Drinking Water Act (1974), all of which either expanded the requirements of previous acts or created new environmental legislation that serves to shape EPA's authority and responsibility.

B. CHRONOLOGY FROM 1972 TO 1976

After the passage of Public Law 92-500, the executive branch of the Commonwealth of Massachusetts was reorganized, resulting in the formation of the Executive Office of Environmental Affairs (EOEA). The Metropolitan District Commission (MDC) became one of five Departments of EOEA, with the MDC Sewerage Division the operation and maintenance agency for the Metropolitan Sewerage District facilities. In March 1973, TCE, Inc. completed a report entitled "Structural Evaluations and Ecological Observations in Boston Harbor." That investigation found that many discharge ports on the Deer Island "New Outfall" (completed in 1968) were clogging and required remedial action.

In May, C. E. Maguire, Inc. completed a "Report on the Water Quality Improvement of the Boston Back Bay Fens" for the Massachusetts DWPC. The study found the Back Bay Fens Pond to be grossly polluted with approximately 150,000 cubic yards of accumulated sludge comparable to the sludge removed by primary clarification of wastewater. Gas bubbles and foul odors were apparent due to decomposing sludge, the stench of which was reported to be intolerable during warm summer days. Higher than normal concentrations of toxic metals were found in the sludge sediment and were seen as a possible threat to efforts to clean the Charles River. Dissolved oxygen was found to be only 2.5 mg/l throughout the Fens Pond in November 1972 and would be lower during summer. In the vicinity of the Boston Gate Houses, the total coliform count in the water was found to be one million per 100 milliliters of water. The study concluded that the major source of pollution to the Fens Pond emanates from the sanitary waste component of the Stony Brook conduit combined sewer overflows at Boston Gate House No. 1.

The Maguire report recommended a $509,000 immediate improvement project for the Back Bay Fens Pond system that included repairing and improving various overflows, tide gates, and sluice gates, adding bar racks and sludge barriers to prevent debris and sludge from entering the Fens Pond, dredging of settled sludge in Fens Pond, adding a subsurface diffused aeration system at Boston Fens Gate House No. 1, and diverting the main flow of the Muddy River through the Back Bay Fens. It also recommended future actions for consideration after immediate improvements had been made, Reference 1.36.

On July 27, 1973, the Massachusetts Legislature enacted the 1973 amendments to the Massachusetts Clean Waters Act. That Act established the power and duties of the Massachusetts Division of Water Pollution Control (DWPC). The Act authorized the DWPC to make a grant equal to fifteen percent of the eligible costs of a water pollution abatement facility that is consistent with local planning and approved by EPA for a federal construction grant of seventy-five percent under the Federal Water Pollution Control Act. Under certain conditions grants could be made up to 90 percent of project cost.

In August 1973, Havens and Emerson, Ltd. completed a report entitled "A Plan for Sludge Management" for the Metropolitan District Commission. That report evaluated three sludge management methods for disposal of sludge from the Deer Island and Nut Island treatment plants, as had been recommended in the 1972 preliminary study by the Boston Harbor Pollution Task Force. The 1973 engineering study recommended a two-phase sludge management program, Phase I for primary sludge and Phase II for future secondary sludge.

The recommended Phase I plan (design year 1985) would continue anaerobic digestion of primary sludge at Nut Island and Deer Island. Digested sludge from Nut Island would be pumped approximately 4.2 miles across Boston Harbor to Deer Island. At Deer Island, the sludge from both plants (128 dry tons/day in 1985) would be combined and incinerated in two multiple hearth incinerators (a third incinerator would be for standby). It was recommended that incinerator ash be disposed by filling a man-made lagoon on the western edge of Deer Island (this method of ash disposal was rejected by an EPA EIS on the project in 1976). The Phase II facilities would accommodate secondary sludge and would include dissolved air flotation concentration of waste activated sludge and sludge storage at both islands. Combined primary and secondary sludge from both plants (429 dry tons/day in 1995) would be incinerated in expanded incineration facilities at Deer Island, Reference 1.37.

The completion of the 1973 MDC Plan for Sludge Management satisfied the sludge management planning requirement of the 1972 "Three Party Agreement" with respect to the Deer Island and Nut Island MDC facilities.

1974

In April 1974, Camp, Dresser and McKee, Inc., completed a sewer system improvement study for the City of Somerville. The study resulted after the DWPC placed the City of Somerville under a State order in April 1972 to fix the tidegates on its overflow structures and to begin procedures to abate its overflow problem. CDM recommended a two-phase sewer system improvement program for the City of Somerville that included (1) repair of tide gates and partial separation of combined sewers and (2) additional partial separation of sewers. Under the partial separation plan, the existing combined sewers would remain in service as combined sewers but would carry substantially reduced volumes of stormwater. Overflows from the City of Somerville were estimated to be reduced in frequency to once in 10 years. Total estimated capital cost of both phases combined was $20,528,000 in 1974 dollars, Reference 1.38.

On May 13, 1974, the Commonwealth of Massachusetts published the DWPC's "Rules and Regulations for the Establishment of Minimum Water Quality Standards and for the Protection of the Quality and Value of Water Resources." The 1974 Water Quality Standards revised the 1967 State water quality standards and established specific criteria for the various receiving water classifications (as established in 1967). The 1974 Water Quality Standards apply to dissolved oxygen, sludge deposits-scum-oil-grease, color and turbidity, total coliform bacteria, taste and odor, pH, allowable temperature increase, chemical constituents (general toxicity), and radioactivity. There were no specific total coliform bacteria limits placed on Class "C" and Class "SC" waters that are subject to urban runoff and combined sewer problems, "which have not yet been solved," Reference 1.39.

Havens and Emerson, Ltd., in October 1974, prepared an "Environmental Assessment Statement for a Plan for Sludge Management" for the MDC. The Environmental Assessment summarized the economic and environmental characteristics of the three sludge management alternatives considered in Havens and Emerson's 1973 engineering study plus the no-project alternative. Construction of sludge incineration facilities on Deer Island for incineration of sludge from MDC's Deer and Nut Island treatment plants was selected as the most cost-effective plan. Compared to land application or wet oxidation, the incineration alternative was found to have the least capital cost ($53,040,000) and net equivalent annual cost ($4,898,000), the latter being based on a $2,540,000 annual credit for electrical power production from waste heat recovered after sludge incineration, Reference 1.40.

1975

During 1975, work on the Eastern Massachusetts Metropolitan Area (EMMA) study continued. Some of the twenty-three Technical Data Volumes of the EMMA study were completed while preparation of the remaining volumes and the Main Report continued.

As part of the preparation of an EIS, the EPA Region I held two public workshops to discuss potential environmental impacts of the proposed MDC sludge management plan for the Deer Island and Nut Island sewage treatment plants. The first workship was held on September 4, 1975, and the second was held on November 10, 1975.

In addition to the work on the EMMA Technical Data Volumes, other sewerage system improvement planning documents have been completed, including the following:

1. "Study of Pollution Control Alternatives for Dorchester Bay" by Process Research, Inc., for MDC (20 March 1975), Reference 1.41.

2. "1975 Supplement to the 1967 Report on Improvement to the Boston Main Drainage System" by Camp, Dresser, and McKee, Inc., (November, 1975), Reference 1.42.

3. "Facilities Plan Report for Sanitary Sewer System in Boston Downtown Waterfront Faneuil Hall Project" by Schoenfeld Associates Inc., for the Boston Redevelopment Authority (3 December 1975), Reference 1.43.

The 1974 "Needs" survey, revised May 1975, was reported to the Congress. It showed needs in categories I through V in the amount of $2,964,000,000 for Massachusetts, exclusive of needs for stormwater facilities which were another $3,121,000,000, expressed in June 1973 dollars, Reference 1.44.

Following designation by Governor Dukakis, the EPA awarded the Metropolitan Area Planning Council (MAPC) a $2.3 million grant in June to conduct a two-year "Areawide Waste Treatment Management" planning study for 92 of the 109 Cities and Towns in the Metropolitan Boston Area of Eastern Massachusetts, in accordance with Title II, Section 208 of Public Law 92-500. The Section 208 Study focuses on diffuse, "non-point" pollution sources such as urban runoff, erosion and failing septic tank systems as well as specific "point" sources such as industrial and municipal discharges. The stated commitment is "to clean up the region's waters to be fishable and swimmable by 1983."

1976

"Classification and Segmentation of Massachusetts River Basins and Coastal Zones 1976" was published in May by the Water Quality Section of the Massachusetts DWPC in Westborough. This document presents a reclassification of the waters of the Commonwealth as dictated by the May 1974 revisions to the Massachusetts Water Quality Standards, and includes the "anti-degradation provision" of no new discharges upstream of the most upstream municipal waste discharges, Reference 1.45.

After joint Public Notice (MA-92-76) and comment period, Region I of EPA and DPWC of the Commonwealth of Massachusetts held a public hearing February 18, 1976 in Boston's Faneuil Hall to consider the issuance of a NPDES permit to the Metropolitan District Commission, pursuant to Section 402 of Public Law 92-500 and application made January 15, 1974. The draft permit dated January 9, 1976, would revoke the existing permits for the primary treatment plants at Deer Island and at Nut Island issued to the MDC April 2, 1975 and due to expire June 30, 1977. The draft permit was designated Federal Permit No. MA 0102351, State Permit No. 180. The expiration date had not been determined, and could be modified before being issued. Issuance or modification was noted as an administrative decision. The draft permit differed from the existing permits in that it included more point sources, and it included a time schedule for compliance, Reference 1.46.

The draft permit would authorize the following discharges:

1. Discharges from the Deer Island Treatment Plant, through 2 sewage and sludge outfalls, and 3 raw sewage reliefs to Boston Harbor.

2. 19 Sewer overflows to Boston Harbor and tributaries (18 in the Deer Island System and 1 in the Nut Island System).

3. Discharges from the Nut Island treatment plant, through three sewage outfalls, 1 emergency relief, and 1 sludge outfall.

4. Discharge of combined sewer overflows from the Cottage Farm Stormwater Detention and Chlorination Station to the Charles River.

5. The next item in the draft Permit calls for the MDC to:

   > "Check all tide gates owned and controlled by them at least twice a year to see that they are working properly and repair them, if necessary." Reporting is a part of this item.

6. Discharge of combined sewer overflows from the Somerville Marginal Conduit and Pretreatment Facility to the Mystic River.

7. Proposed Combined Sewer Overflow Discharges:

   a. Charles River Marginal Project (proposed 1979) combined sewer overflow to the Charles River/ Boston Inner Harbor.

   b. Dorchester Bay Combined Sewer Overflow Facility (proposed 1981) discharge to Dorchester Bay.

   c. Charles River Combined Sewer Overflow Facility (proposed 1983) discharge to the Charles River or its tributaries.

   d. Neponset River Combined Sewer Overflow Facility (proposed 1883) discharge to the Neponset River, and

   e. Boston Inner Harbor Combined Sewer Overflow Facility (proposed 1986) discharge to Boston Inner Harbor.

8. The last item listed is the optional advanced waste treatment plants (proposed 1984). If the option to build satellite plants is selected based on the EIS, requirements are given for:

    a. Middle Charles River Wastewater Treatment Plant (Wellesley Area) effluent, and

    b. Upper Neponset River Wastewater Treatment Plant (Canton Area) effluent.

Specific requriements would vary. For example, the draft permit would allow a monthly average BOD of 165 mg/l from the existing Nut Island Plant until February 1, 1985 (primary treatment) and 30 mg/l of BOD after February 1, 1985 (secondary treatment). The Deer Island BOD allowance was 140 and 30 for the same dates.

There were no effluent limitations (nor treatment requirements) specified for the 19 existing permitted sewer overflows which are now untreated. The overflows from the Cottage Farm and Charles River Marginal Facilities however were required to have:

> "as a minimum, screening, chlorination and detention prior to discharge. All flows discharged shall contain a minimum chlorine residual of 1.0 mg/l at all times."

No detention would be required at the Somerville Marginal Conduit and Pretreatment Facility.

The draft permit contained an implementation schedule regarding:

1. State Legislative Requirements,
2. Conformance with NEPA,
3. Sewer Use Ordinance and Industrial Source Control,
4. Survey of Contributing Industries,

5. Bypasses and Overflows,

6. Infiltration/Inflow Analyses, and

7. Construction Projects.

The construction projects schedule gives dates for initiating and completing Steps 1, 2, and 3 for the selected facilities, through February 1, 1985. The permit and the schedule therein correspond to priority items 1-15 inclusive of the EMMA Recommended Plan (as described in Chapter 3 of this Report). Progress reports would be required twice a year.

The last section of the draft permit's special conditions is on Monitoring and Reporting. This Section specified minimum frequency of analysis, sample type, and parameters to be analysed from many of the discharges.

The General Conditions Section of the draft permit includes a requirement for an alternate source of power to provide a minimum of primary treatment plus disinfection for all wastes discharged during failure of the primary power source. The General Conditions also require that collected sludges and screenings removed from liquid waste be prevented from entering into navigable waters or their tributaries.

Appended to the draft permit was the MDC construction staging program for the 52 projects in the EMMA Recommended Plan, the document upon which the construction projects implementation schedule was based.

At the public hearing relative to the proposed MDC NPDES permit the issues considered were:

1. Do the proposed effluent limitations represent best practicable control technology currently available as required by July 1, 1977, for pretreatment of industrial waste prior to discharge into public sewers?

2. Are the proposed effluent limitations stringent enough to meet water quality Standards by July 1, 1977?

3. Are the proposed schedules for compliance reasonable?

4. What should be the date of Expiration of the Permit?

In June 1976, the EMMA Main Report (dated March 1976) and the twenty-one Technical Data Volumes (dated October 1975) were released, Reference 1.47. (Chapter 3 of this Report is devoted to the EMMA Study.)

The EMMA Recommended Plan includes expansion of the MSD with fifty construction projects having an estimated capital cost of $855,359,000 (at ENR 2200) and $24,900,000 annual operation and maintenance cost.

The EMMA Study also identifies the need for additional municipal facilities in the peripheral area at a capital cost of $268 million with annual operation and maintenance costs of $17 million, exclusive of costs of local collection sewers.

On August 12, 1976, the new NPDES permit was issued to the MDC. A major difference between the issued permit and the draft is that requirements in the issued permit were made to comply with Public Law 92-500. Therefore, while the draft permit outlined the construction schedule of many projects having completion dates well past the year 1977, the issued permit mandates completion of all secondary treatment facltiies, overflow projects, interceptor relief, and sludge management projects by July 1, 1977.

Other differences between the two permits are:

1. The issued permit includes monitoring requirements for the planned Charles River Marginal Conduit Stormwater Control Project, although no treat-

ment requirements are stated.

2. No effluent limits are given in the issued permit for the four other combined sewer overflow facilities proposed in the EMMA recommended plan.

3. The issued permit does not include requirements for the MDC to obtain state legislative approval of the steps to be performed in compliance with the NPDES permit.

4. The issued permit does not include a compliance schedule for completion of the required Environmental Impact Statements, as mentioned in the draft permit.

5. The issued permit does not include an implementation schedule for the analysis of the infiltration/inflow problem in the MDC sewer system.

6. Several compliance dates are modified in the new permit, relating to report submittal, construction staging, and the attainment of effluent limitations. (Points 2-5 are addressed in the ECSL mentioned below).

The NPDES permit was accompanied by an Enforcement Compliance Schedule Letter (ECSL) from EPA and DPWC to the MDC and conditionally accepted by the MDC. The ECSL states that:

> "EPA and MDC concluded that it cannot, despite all reasonable best efforts, achieve the limitations from the discharge between the final effective date of the Permit and July 1, 1977."

Accordingly, the ECSL proceeds to set forth a revised compliance schedule. Even though many of the completion dates for projects related to the attainment of "best practicable control technology" (BPT) extend past 1977, the Letter states that:

> "The compliance schedule contained in the permit notwithstanding, this Agency, in the exercise of its prosecutional discretion, will not take action against the Permittee... with respect to the Permittee's failure to achieve the limitations on and after July 1, 1977,... provided that the permittee complies with the following conditions..."

The conditions set forth, modify the newly issued NPDES permit so as to make it very similar to the earlier draft permit, with several of the attainment dates postponed.

Although the ECSL allows conditional postponement of the Federally mandated July 1, 1977 deadline, it does not:

> "...preclude the initiation of an action, pursuant to section 505 of the act, by a third person other than the Agency to enforce the Permit's requirements to achieve the limitations by July 1, 1977."

The MDC conditionally accepted the terms of the ECSL upon EPA's recognition that compliance is contingent upon project authorization and appropriations, and upon timely completion and approval of the EIS's and grant applications. The MDC also did not accept responsibility for delays caused by "third party" actions against the MDC.

The ECSL which was issued August 11, 1976, the first in the country, constitutes a commitment of the State to enable the MDC to carry out a program to clean up Boston Harbor and the Charles and Neponset Rivers; facilities construction is to be completed by July 1984 and operational by October 1984, according to Environmental Reporter Vol. 7, No. 17 and 18.

August 19, 1976, the Division of Water Pollution Control published a legal notice in the Boston Herald American that a Public Hearing would be held

September 20, 1976 in the State House, pursuant to Section 106 of the Federal Water Pollution Control Act of 1972 and Chapter 30A, Section 11A of the General Laws of the Commonwealth, to hear comments on the Annual Program Plan for Fiscal Year 1977, Reference 1.48. The notice included the following criteria for establishing priorities under the Acts:

1. Eligible Projects are defined as projects which have been submitted to DWPC and meet the requirements of DPWC and the rules and regulations of EPA.

2. Certification for Priority. To be considered, new projects must be submitted at least 2 months before the start of the fiscal year, projects will be certified annually for grants in the maximum amount eligible as requested in the application to the extent of the funds made available to the State, and priorities will be given to eligible projects based on criteria explained below.

3. Criteria system for ranking projects.

    a. First consideration will be given to projects that will provide a minimum of secondary treatment or are needed to meet water quality standards. These are wastewater treatment plants, outfall sewers, major interceptors. Major pump stations and force mains.

    b. Projects for the separation of combined sewers and treatment of overflows are a lower priority and will not be considered unless a project will result in a major improvement in quality of the receiving waters and adequate Federal funds are available.

    c. When the reduction of infiltration is an effective cost solution and is necessary, it may be considered for funding.

    d. Collection systems alone will have a lower priority than those mentioned above, and only for communities in existence October 18, 1972. However, when a collection system is to be constructed in conjunction with a treatment plant it may be considered to be a part of the treatment plant project.

4. Project Priority List. An enumeration and ranking of potential municipal construction projects in the State was published in the Notice. The list consisted of the "Active List" which could be funded with available funds, and an "Extended List" which could be funded if additional funds became available. The lists contain Step 3 projects and only those Step 1 and Step 2 projects of a value of $10,000 or more. (Funds are reserved for Step 1 and Step 2 projects under $100,000.) Projects were ranked according to points given to 12 types of projects and to 6 kinds of effects on uses, waters, health hazards and nuisances they would abate, and on population served.

   (a) The Active List contains 86 projects in the State of which 30 are in the EMMA Study Area summarized as follows:

      (i) Eight are MDC projects,

      (ii) Ten are projects of MDC member communities, and,

      (iii) Twelve are projects in the EMMA Peripheral Study Area (outside the MDC area).

   (b) The Extended List contains 166 projects in the State of which 59 are in the EMMA Study Area.

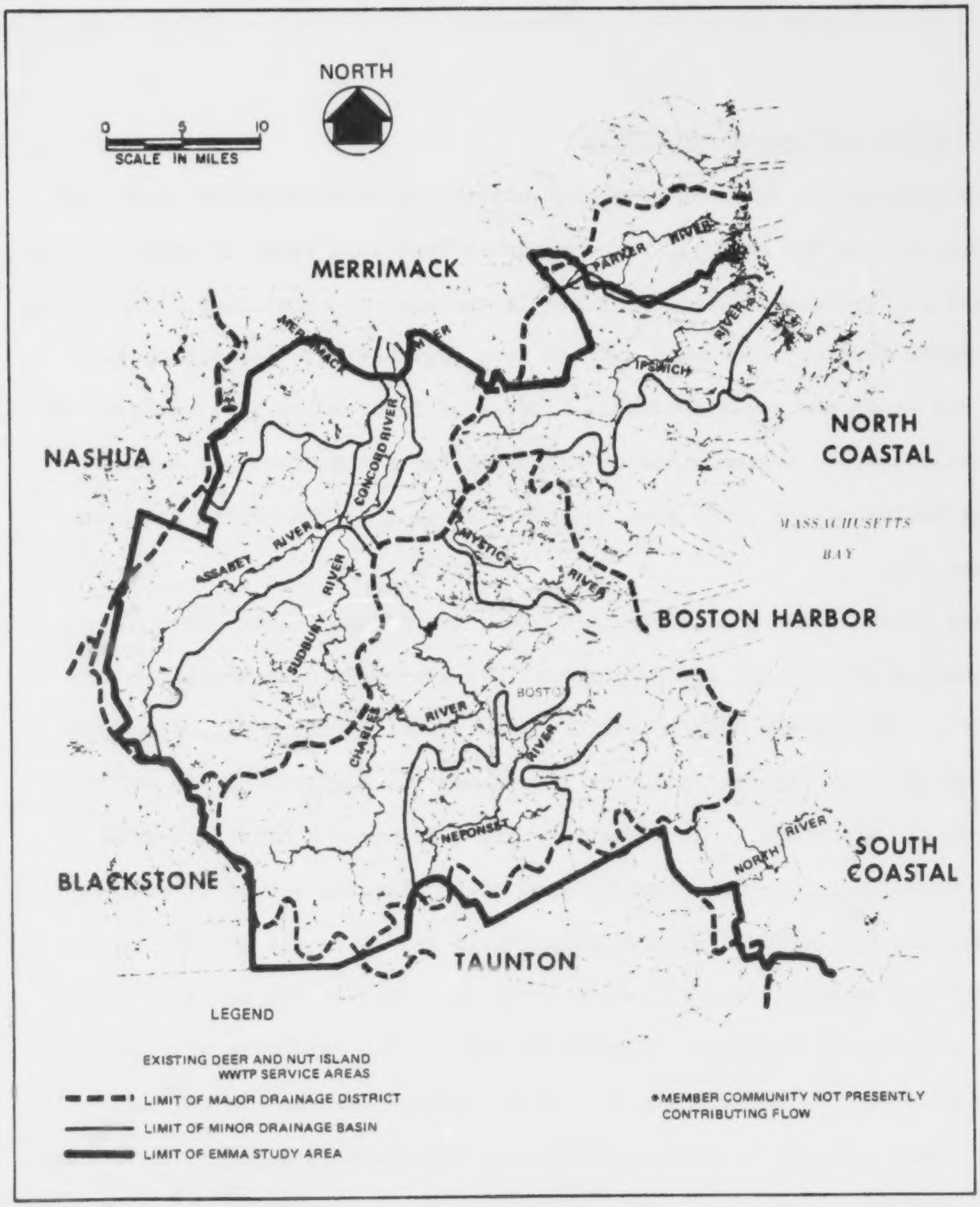
The Fiscal Year 1977 Project Priority list is the first for the State of Massachusetts to have an extended list because for the first time the cost of projects exceeded the remaining grant funds available. (Contingency lists are said to have existed in FY75 and 76 but were apparently unpublished.)

C. EXISTING WASTEWATER FACILITIES

Inventories of existing treatment plants and other sewerage facilities have been made in the past but no complete current list seems to exist for the exact portion of Massachusetts included in the area of this study. Our review of all NPDES permits issued and applied for, together with interim outputs of the 208 study and other available sources of information have resulted in the compilation, by drainage basin, following in this section. A map of drainage basins of the study area as presented in the EMMA Report is shown in Figure 1-1.

The Metropolitan Area Planning Council has divided their Metropolitan Area Planning District of 92 communities into eight (8) watersheds for purposes of conducting the 208 Project Study as shown in Figure 1-2, Reference 1.49. The boundary for this Study is also shown for comparison. In addition to the eight watersheds used by MAPC we have delineated a ninth sub-area namely "Boston Harbor" to correspond with basin planning sub-areas used by the Massachusetts DWPC, Reference 1.50. Table 1-1 lists the 109 Cities and Towns and the three Districts of this study according to the basin in which each is principally situated. Communities within the MAPC were assigned to a basin according to Reference 1.51. Those communities outside the MAPC boundary were assigned to a basin by Kennedy Engineers on a geographical basis.

A listing of municipal treatment works with their rated or design capacity is shown in Table 1-2 as drawn from numerous reports and the NPDES permit files. The number of major industrial discharges (95) and discharges from


NORTH
0 5 10
SCALE IN MILES
MERRIMACK
NASHUA
NORTH COASTAL
BOSTON HARBOR
BLACKSTONE
SOUTH COASTAL
TAUNTON
MASSACHUSETTS BAY
PARKER RIVER
IPSWICH RIVER
MERRIMACK RIVER
CONCORD RIVER
ASSABET RIVER
SUDBURY RIVER
MYSTIC RIVER
CHARLES RIVER
NEPONSET RIVER
NORTH RIVER
BOSTON
LEGEND
EXISTING DEER AND NUT ISLAND WWTP SERVICE AREAS
LIMIT OF MAJOR DRAINAGE DISTRICT
LIMIT OF MINOR DRAINAGE BASIN
LIMIT OF EMMA STUDY AREA
*MEMBER COMMUNITY NOT PRESENTLY CONTRIBUTING FLOW

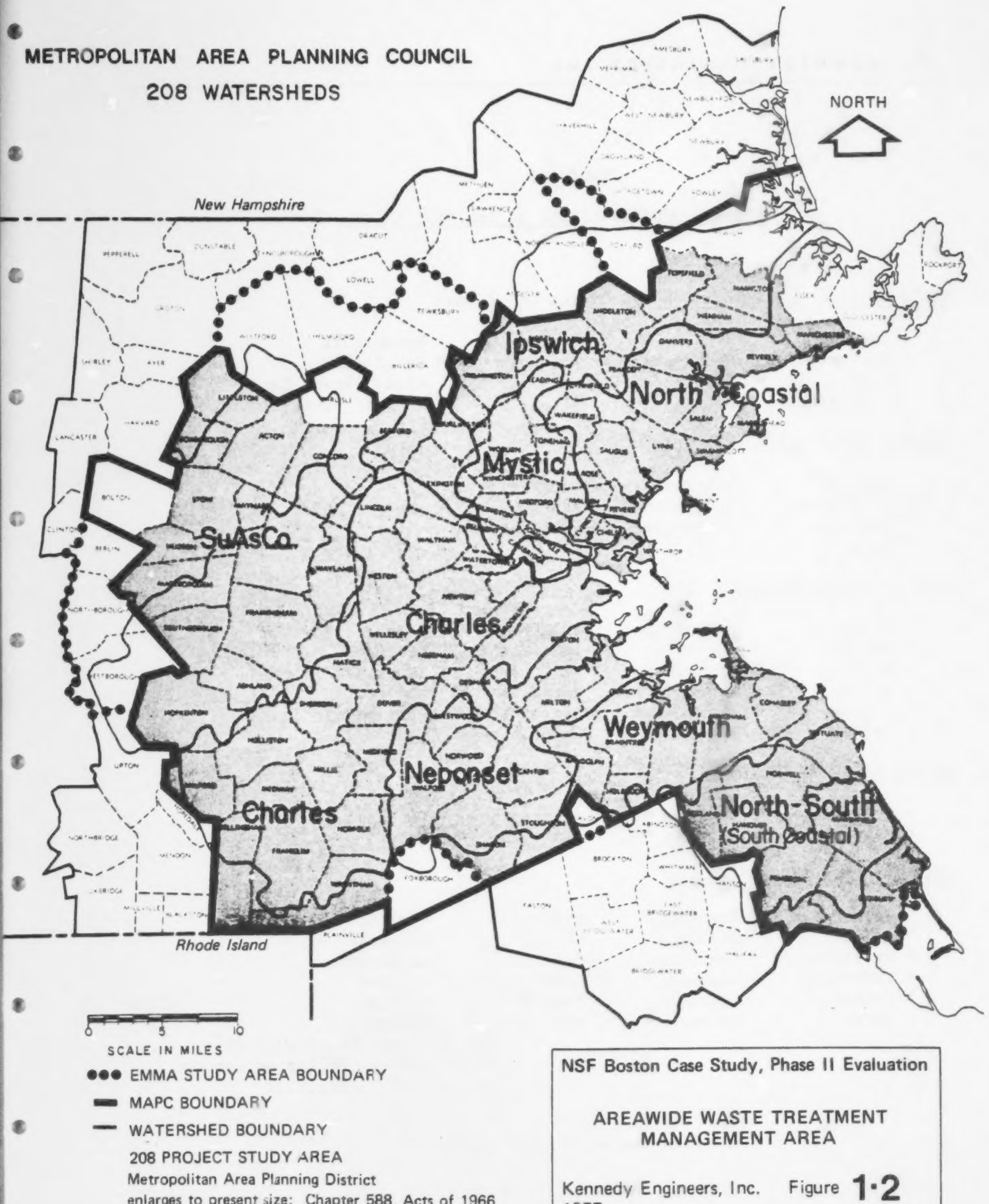
NSF Boston Case Study, Phase II Evaluation

DRAINAGE BASINS

Kennedy Engineers, Inc. Figure **1·1**
1977

METCALF & EDDY

METROPOLITAN AREA PLANNING COUNCIL
208 WATERSHEDS


NORTH
New Hampshire
Rhode Island
Ipswich
North Coastal
Mystic
SuAsCo
Charles
Weymouth
Neponset
Charles
North-South
(South Coastal)
0 5 10
SCALE IN MILES
●●● EMMA STUDY AREA BOUNDARY
▬ MAPC BOUNDARY
— WATERSHED BOUNDARY
208 PROJECT STUDY AREA
Metropolitan Area Planning District
enlarges to present size: Chapter 588, Acts of 1966
Initial Legislation Chapter 688, Acts of 1963

Source: 208 PROJECT STUDY,
Metropolitan Area Planning
Council, May 1976

NSF Boston Case Study, Phase II Evaluation

AREAWIDE WASTE TREATMENT
MANAGEMENT AREA

Kennedy Engineers, Inc. Figure **1·2**
1977

TABLE 1-1

STUDY AREA MUNICIPALITIES BY DRAINAGE BASIN

NORTH COASTAL DRAINAGE BASIN (14 Cities and Towns)

Beverly
Danvers
Essex
Gloucester
Lynn
Manchester
Marblehead
Nahant
Peabody
Rockport
Salem
Saugus
Swampscott
* Wakefield
Also: South Essex Sewer District

IPSWICH RIVER BASIN (11)

Boxford
* Burlington
Hamilton
Ipswich
Lynnfield
Middleton
N. Reading
* Reading
Topsfield
Wenham
* Wilmington

SuAs Co. DRAINAGE BASIN (24)

Acton
* Ashland
* Bedford
Billerica
Bolton
Berlin
Boxborough
Carlisle
Chelmsford
Concord
* Framingham
Hopkinton
Hudson
Littleton
Marlborough
Maynard
Northborough
Southborough
Stow
Sudbury
Tewksbury
Wayland
Westborough
Westford

MYSTIC RIVER BASIN (8)

* Arlington
* Malden
* Medford
* Melrose
* Somerville
* Stoneham
* Winchester
* Woburn

CHARLES RIVER BASIN (24)

Bellingham
* Belmont
* Brookline
* Cambridge
* Dedham
Dover
Franklin
Holliston
* Lexington
Lincoln
Medfield
Medway
Milford
Millis
* Natick
* Needham
* Newton
Norfolk
Sherborn
* Wellesley
* Watertown
* Waltham
Weston
Wrentham
Also: Charles River Pollution Control District

(continued on next page)

TABLE 1-1 (Cont'd)

BOSTON HARBOR (6)

* Boston
* Chelsea
* Winthrop
* Everett
* Quincy
* Revere

Also: Metropolitan Sewerage District

NEPONSET RIVER BASIN (7)

* Canton
* Milton
* Norwood
Sharon
* Stoughton
* Walpole
* Westwood

WEYMOUTH RIVER BASIN (8)

Avon
* Braintree
Cohasset
* Hingham
* Holbrook
Hull
* Randolph
* Weymouth

SOUTH COASTAL BASIN (7)

Duxbury
Hanover
Marshfield
Norwell
Pembroke
Rockland
Scituate

* denotes member of Metropolitan Sewerage District

TABLE 1-2

MUNICIPAL PLANTS AND MAJOR DISCHARGES

BASIN	Major Industrial Discharges	Public Institutional Discharges	Municipal Treatment Plants			
			Number	Community	Type	MGD
NORTH-COASTAL	19	0	3	Manchester	Sec.	0.7
				Rockport	Sec.	2.6
				Swampscott	Pri.	2.7
IPSWICH	5	0	1	Ipswich	Pri.*	2.0
SuAsCo	17	2	8	Billerica	Sec.	0.1
				Billerica	Sec.	0.8
				Concord	Pri.	1.1
				Hudson	Sec.	2.0
				Marlboro E.	AWT	5.5
				Marlboro W.	Sec.	2.0
				Maynard	Sec.	1.3
				Westborough	Sec.	1.2
MYSTIC	7	0	0			
CHARLES	10	5	4	Franklin	Sec.	0.7
				Medfield	AWT	1.5
				Milford	Sec.	4.0
				Millis	Sec.	0.3
BOSTON HARBOR	25	3	5	MDC Deer Isl.	Pri.	343
				MDC Nut Isl.	Pri.	112
				MDC Cottage Farm	CSO	233
				MDC Somerville	CSO	160
				Boston Moon Isl.	CSO	180
NEPONSET	9	0	0			
WEYMOUTH	1	5	0	Cohasset	Sec.	0.1
NORTH-SOUTH	4	2	3	Marshfield	Pri.	0.1
				Rockland	Sec.	1.0
				Scituate	Land	1.0
TOTALS	95	17	24			1059.0

* (DWPC advises that Ipswich is constructing a secondary treatment plant).

public institutional facilities (17) are obtained from preliminary data of the MAPC 208 project study. These data do not agree with EPA records, Reference 1.52. Where EPA lists 19 NPDES Permits for the Boston Harbor area, the table shows 33 discharges. Where EPA files contain 19 permits for the Neponset river basin the table shows 9.

The industrial and institutional discharges shown in each basin do not include those connected to municipal sewer systems. During the Phase I study, review of available reports and local interviews indicated very little information about the number of industries discharging to municipal sewers or the quantity and strength of such industrial wastes. MAPC estimated that there are roughly 8,000 industrial connections to local sewers of member communities tributary to the MSD system.

Recently released data generated from an MDC Industrial Waste Survey and Inspection Program shows, as of August 1976, eighteen of their member communities have no industries discharging more than 50,000 gallons per day, while thirty-five communities have a total of 115 such industries which discharge 36.8 mgd. (This is eight percent of the flow at the Deer and Nut Island Plants.) About one-half of the flow from major industries originates in Cambridge and Boston, although the second largest industry is in Walpole. It has been estimated that another 25 to 30 mgd originates from small industries, each contributing less than 50,000 gallons per day.

In Table 1-2 an industry is considered "major" if it discharges wastewater at flow greater than 50,000 gpd. EPA includes strength and other considerations in its definition of "major" discharges as is evidenced by the very small number of industries labeled as "major" in the compilation of issued National Pollutant Discharge Elimination System (NPDES) permits in the EPA computer records.

Institutional discharges include wastes from airports, hospitals, military facilities, waterworks facilities, prisons, and similar installations.

It should be noted that the "Secondary" classification of a municipal treatment facility as used in Table 1-2 is not necessarily in conformance with the present EPA definition. Secondary as used here implies only that the plant was designed to utilize a biological method of waste treatment (activated sludge or trickling filter). It does not infer that the facility is meeting the EPA's definition of secondary treatment, although this may be true in some cases.

Municipal wastewater treatment facilities are also classified by the Board of Certification for purposes of determining the minimum grade of certified operator required to be in responsible charge of each facility. There are 277 facilities listed in the State of which 77 are located in our Study Area, Reference 1.53. The ones in the Study Area may be further categorized as follows:

Industrial Plants	27
Public Institutional Plants	22
Municipal Plants	28
TOTAL	77

The municipal facilities from this source of information and their classifications are listed by drainage basin in Table 1-3. The list contains

TABLE 1-3

CLASSIFIED MUNICIPAL FACILITIES

Municipality	Classification
North Coastal Drainage Basin (6)	
Lynn Pumping Stations	1
Gloucester	6*
Manchester	4
Rockport	5
Swampscott	4
South Essex Sewer District	7*
Ipswich River Basin (1)	
Ipswich	4
SuAsCo Drainage Basin (6)	
Billerica	5
Concord	3
Hudson	4
Marlboro East and West combined	6
Maynard	6
Westborough	4
Mystic River Basin (0)	
Charles River Basin (5)	
Franklin	4
Medford	5
Milford	4
Millis	3
Charles River Pollution Control District	6*
Boston Harbor (5)	
MDC Deer Island	7
MDC Nut Island	7
MDC Cottage Farms Station	4
MDC Pumping Stations	1
City of Boston Pumping Stations	1
Neponset River Basin (0)	

TABLE 1-3 (Continued)

CLASSIFIED MUNICIPAL FACILITIES

Municipality	Classification
Weymouth River Basin (2)	
Cohasset	3
Hull	6*
South Coastal Drainage Basin (3)	
Marshfield	2
Rockland	7
Scituate	4
	28

Note: An asterisk (*) denotes classification if a future facility is now under construction. (The Gloucester Plant is not under construction according to EPA. It is noted that the NPDES permit required commencement of construction by October 30, 1975 however.)

the classification for four facilities not yet operational. The list also shows pumping stations for three agencies. The list does not include the MDC Somerville stormwater chlorination station nor the City of Boston Moon Island detention station, which may be classified as pumping stations.

The same Board lists 178 certified operators in the State holding grades 5, 6, and 7 (the three highest grades), Reference 1.54.

A description of existing facilities in each of the nine basins follows:

1. NORTH COASTAL DRAINAGE BASIN

The North Coastal drainage basin, has fourteen cities and towns with a 1970 combined population of 374,000. Most of the communities are completely sewered, as only Manchester, Gloucester, Rockport and Essex have substantial unsewered populations according to the EMMA Report. The towns of Manchester, Rockport and Swampscott are served by local treatment facilities, while Wakefield is a member of the Metropolitan Sewer District, with domestic wastes collected by that town treated by the MDC facility at Deer Island.

Much of the sewage collected in the North Coastal basin is discharged to the Atlantic Ocean without any treatment. The National Pollutant Discharge Elimination System (NPDES) permits, issued jointly by the Environmental Protection Agency (EPA) and the Massachusetts Division of Water Pollution Control (DWPC) allow continuous, untreated discharge from Lynn (25.3 mgd), and Marblehead (2.5 mgd). In addition, the South Essex Sewer District, (SESD), which is a regional agency formed in 1925 to treat and dispose of the flows from Beverly, Danners, Marblehead, Peabody and Salem, presently discharges 26 mgd of screened sewage to the Salem-Beverly Harbor according to the DWPC Basin Plan for this

Area. The SESD also provides service to State institutions and the Ferncraft development in the town of Middleton located in the Ipswich River Basin, Reference 1.47.

Numerous, intermittent overflow points exist in the basin for combined sewage (during wet weather) and for bypassing (during mechanical power failures). In fact, more than 40 overflow points exist in the North Coastal basin.

The only comprehensive survey found of industries that discharge into the region's waters is contained in the EMMA report. Nineteen major discharges are reported in the basin, although it should be noted that EMMA categorizes significant industrial discharges differently than EPA. Numerous small industrial discharges are believed to exist. No major discharges from institutions are thought to exist since none are mentioned in the available reports.

2. IPSWICH RIVER DRAINAGE BASIN

The population of the Ipswich River Basin (117,900 in 1970) is predominately unsewered. Of the three communities that have sewers, two (Burlington and Reading) are members of MSD and discharge their wastewaters to the Deer Island treatment plant. The town of Wilmington is also a member of MSD, but is only minimally sewered at this time. The population of the town of Ipswich is almost 40 percent sewered, and has a primary treatment facility with a discharge to the Ipswich River. No other treatment plants are shown in the basin.

The EMMA study reports five significant industrial discharges into the basin's water. No mention is made of institutional discharges within the eleven communities in the basin.

3. SuAsCo DRAINAGE BASIN

The SuAsCo drainage basin contains the Sudbury, Assabet and Concord Rivers. Twenty-four cities and towns with 346,400 people (1970 estimate) comprise the SuAsCo drainage basin. All but nine communities are completely unsewered, and three of these (Ashland, Bedford and Framingham) are MSD members served by either Deer or Nut Island. A sewer connection moratorium exists in Framingham due to lack of capacity, according to DWPC.* The six other towns (Concord, Hudson, Marlborough, Maynard, Billerica and Westborough) operate separate treatment facilities ranging from primary treatment to advanced waste treatment.

Seventeen industries discharging large waste flows into surface waters have been identified by the EMMA study.

The MAPC 208 study data show two institutional discharges in Concord. One of these discharges (Middlesex School) receives advanced waste treatment, while the other (Concord MCI) receives secondary treatment.

4. MYSTIC RIVER DRAINAGE BASIN

All of the eight communities in the Mystic River Drainage Basin belong to the MSD, and virtually all of the population of the region is sewered (with the exception of Woburn which is the only 75 percent sewered). There are no municipally owned sewage treatment facilities in the basin.

Seven major industrial discharges occur in the towns of Woburn,

---

* (The moritorium allows one gallon of wastewater to be added with removal of two gallons of I/I.)

Winchester, Somerville and Malden according to Volume 3B of the EMMA Study. Intermittent combined sewer overflows are known to occur at no less than 12 points in the basin, with most of the overflows occurring in Somerville and Stoneham.

Lower portions of the Mystic River, as well as portions of the Charles River, Neponset River and Weymouth River drainage basins are classified hereinafter as the Boston Harbor Region.

5. CHARLES RIVER DRAINAGE BASIN

The twenty-four towns in the Charles River Drainage Basin have a combined population of 652,600 (1970 estimate). While some communities are completely sewered (Cambridge, Newton and Watertown), others have no collection system at all (Bellingham, Dover, Lincoln and others).

Eleven communities are served by the Nut and Deer Island treatment facilities. According to DWPC, there is a sewer connection moratorium in Natick due to lack of capacity.

In 1973, the communities of Franklin and Medway joined together to form the Charles River Pollution Control District (CRPCD), with the northern part of Bellingham joining later. There is no regional treatment facility at present, although a $19,000,000 EPA grant was awarded to CRPCD on May 28, 1976 for the construction of an advanced waste treatment facility in Medway.

Three municipally owned secondary treatment plants exist in the Charles River basin and an advanced waste facility serves the town of Medfield. The present situation is that all sewered communities except Medway are served by either MSD or a municipal facility, although Medway's population (7800 in

1970) is only 4 percent sewered. Currently, Medway disposes of its sewered wastes by means of an untreated discharge into the Great Black Swamp. Numerous points of intermittent combined sewer overflow occur during wet weather, and raw sewage bypasses occur in Waltham. In addition, bypassing capabilities exist at Milford, and Millis, with at least 24 places in the basin where untreated wastewaters may enter surface waters, according to the DWPC Charles River Basin Plan.

The EMMA study reports ten major industrial discharges in the basin. Five institutions discharge significant volumes of wastes. At least four of these institutions provide some minimal treatment prior to discharge, and two of the facilities have secondary treatment capabilities. The discharges occur in the towns of Natick, Medfield, Norfolk and Wrentham.

6. BOSTON HARBOR REGION

The six communities that constitute the Boston Harbor region are the Cities of Boston, Chelsea, Everett, Quincy, Revere and the Town of Winthrop. All of these communities are sewered (virtually completely) and all are served by the MSD which maintains two primary treatment plants and appurtenant facilities in the region.

The Metropolitan District Commission as a State agency operates the Metropolitan Sewerage District which provides wastewater transport and treatment services to 43 member communities with a population of approximately two million people within a service area of approximately 500 square miles. There are approximately 5,000 miles of local sewers connected to the MSD system at 1800 points. Local wastewater collection systems are owned and operated by the towns and cities that pay a fee for connection to the MSD interceptor and trunk sewers. MSD's facilities include approximately 227 miles of interceptors, trunk sewers and tunnels, eleven pumping stations, two storm water chlorination stations, four pretreatment headworks, and two large primary treatment plants (at Deer and Nut Islands) with pumping stations. The MDC system includes at least 21 overflow locations before treatment, treatment unit bypasses, and four relief outfalls that discharge effluent into shallow waters during high wastewater flow rates and/or at high tides. The MSD facilities have inadequate capacity to take all of the wastewater from all of the member communities all of the time and numerous overflows occur both from the MDC system and from sewers of member communities.

The city of Boston still discharges untreated wastewater at three points, and intermittently overflows combined sewage at 74 points according to the City's NPDES permit. In addition, 48 stormwater overflows exist in Boston with the possibility that these discharges contain sanitary sewage as a result of cross-connections. The city also operates holding tanks at Moon Island which are used when flows exceed pumping capacity at Deer Island, discharging untreated combined sewage at ebb tide. Many overflow points in the area are below high tide level and do not have adequate provision to prevent entry of sea water.

The city of Revere discharges untreated combined sewage at two points, and Chelsea has 8 combined overflows which operate during wet weather. Everett also has combined sewers, although no reports of overflows have been found.

The stormwater runoff and water quality modeling done for the EMMA study was based on 69 major overflow outlets into the harbor and tributaries. (Although not all overflow points were explicitly modeled, their flow contributions were reportedly accounted for and aggregated with the larger nearly overflows used in the model.) The peak overflow rate, as reported in Volume 7 of the EMMA Study, has been estimated to be roughly 8400 mgd, based on a one-year design storm as used in EPA's Storm Water Management Model.

The EMMA Study also reports 25 industries, each discharging more than 50,000 gpd of wastewater. Most of these industries are located in Boston, with the remainder in Everett and Revere.

The MAPC Study reveals three points of institutional discharge to Boston Harbor. One of these discharges occurs at Logan Airport which has not been labeled as a "major discharge" by EPA, but has been issued an NPDES permit.* The waste load from the airport is actually quite large considering the waste input from the aircraft shops, terminals, hotels, aircraft holding tanks, and equipment washing areas. The reason for the airport's neglect by EPA might be that there are several points of discharge from the airport, and no one discharge has a flow greater than 50,000 gpd. It is likely that toxic materials exist in waste discharges from the area. It appears that the large volume of airport waste lacks any treatment. Institutional discharges of wastewater also occur from institutions located on several of the Harbor Islands.

No documentation was found of any facilities to handle wastewater from boats and ships.

* (It is noted that planning, grants, and enforcement groups may use different criteria to determine major dischargers.)

7. NEPONSET RIVER DRAINAGE BASIN

All the towns in the Neponset River Drainage Basin (Table 1-1) are sewered to some degree except for Sharon. Similarly, all the towns except Sharon are part of the MSD system. The population of the region was estimated in 1970 to be 141,900.

The town of Norwood has combined sewers, and twelve intermittent overflow points are noted in the town's NPDES permit.

Nine major industrial discharges exist in the towns of Canton, Milton and Walpole. No institutional discharges are noted.

8. WEYMOUTH RIVER DRAINAGE BASIN

Eight towns make up the Weymouth River drainage basin, having a combined 1970 population of 169,500. The town of Braintree is almost completely sewered, but much of the rest of the population in the Basin is unsewered. The towns of Holbrook and Avon have no sewage collection systems at all, yet Holbrook is a member of MSD in anticipation of future sewering.

A 0.086 MGD secondary treatment plant serves the town of Cohasset. All of the other towns in the basin belong to MSD except for Hull which discharges raw sewage to Massachusetts Bay. Bypassing of raw sewage to Broad Cove occurs periodically in the town of Hingham as a result of the combined sewer system being unable to accept large volumes of stormwater. Inflow of water into trunk sewers during high tides also aggravates the problem of sewer overflows.

The EMMA Study documents two major industrial discharges (in Braintree and Weymouth). Five institutional discharges have been identified in the towns of Cohasset, Hull and Weymouth.

9. SOUTH COASTAL BASIN

This basin contains the North River and includes all of the North River drainage basin plus adjacent coastal areas.

Most of the population (84,600 in 1970) in the seven towns of the South Coastal Basin is unsewered. Each of the three partly sewered towns has a municipal facility to perform some degree of waste treatment.

The one major industrial discharge occurs in the town of Rockland. No untreated municipal discharges are reported to exist in the region. Two waterworks discharges of sludge are recorded in the towns of Rockland and Hanover.

D. EXISTING TYPES OF WASTE LOADINGS

In this section are summarized the types of wastewater loadings from municipal point-sources which occur in the Study Area. The estimated costs for facilities required to abate them will be discussed in subsequent chapters of this report.

The following different kinds of municipal point-sources wastewaters create loadings upon Boston Harbor, its tributaries, and adjacent coastal regions from the sewered communities in the Study Area:

1. UNTREATED SEWAGE

Raw Sewage continues to be discharged untreated. We address the category of raw sewage discharges in Chapter 4. They occur due to the following situations:

a. Continuous Discharges. There are continuous discharges of raw sewage from several communities having no treatment facilities whatsoever, although in some instances raw sewage is screened prior to discharge.

b. Intermittent Discharges. There are overflows and bypasses of raw sewage which occur intermittently from several communities. This is generally due either to having inadequately sized treatment capacity or to high infiltration/inflows. Peak diurnal flows and/or wet weather flows as well as equipment failures cause overflows and bypasses of raw sewage. At least one occurence (June 1976) was due to an operators strike. Additional causes are the power failure or mechanical failure. An additional source of raw sewage is discharge of ship wastewaters.

2. TREATED EFFLUENTS

Treated effluents from a wide range of types of municipally owned plants are discharged in the Study Area. They are placed here in three groups as follows:

a. Primary Plants. Primary plants provide treatment principally by plain sedimentation or clarification. The process is usually preceded by some form of screening or comminution and grit removal. About one-third of the Biochemical Oxygen Demand (BOD) and two-thirds of the Suspended Solids (SS) are removed by withdrawal of sludge and scum. These solids are usually digested by a separate process yielding methane gas. Sludge of the two largest plants in the Study Area is discharged into Boston Harbor. At most other plants it is disposed of on land. The effluent from the sedimentation tanks at most plants is partially disinfected either seasonally or year around.

All publicly-owned primary plants are required to be up-graded to provide at least secondary treatment by July 1, 1977. The cost of facilities needed to meet the effluent limitation of secondary treatment are included in the Needs Survey as Facilities Category I.

b. Secondary Effluents. Treatment plants which have a primary process followed by a biological treatment process have historically been termed secondary treatment plants. The biological or secondary process may be a trickling filter or the activated sludge process. The removal of BOD and SS is expected to be in the range of sixty to ninety percent. The EPA definition of secondary treatment now requires a minimum of eighty-five percent removal or removal to thirty milligrams per liter. Most trickling filter plants do not meet this performance requirement and can be thought of as providing an intermediate level of treatment.

Where a plant is required to produce an effluent meeting more stringent requirements, the cost of the extra facilities is in needs Survey Facilities Category II, Advanced Waste Treatment (AWT) facilities.

c. AWT Effluents. Two existing facilities are rated as tertiary or advanced wastewater treatment (AWT) plants. They are both located in the peripheral part of the Study Area. The Easterly Marlborough plant utilizes two-stage activated sludge with chemical precipitation for nutrient removal. Rated at a capacity of 5.5 mgd, the plant was designed for 90% removal of BOD and SS and, in addition, 90% phosphorus removal and nearly complete nitrogen removal. The effluent is discharged to Hop Brook which is a tributary to the Sudbury River. We understand nutrient removal is practical only seasonally to reduce operation costs.

The second AWT plant is at Medfield. It is rated at 1.5 mgd and discharges to the Charles River.

3. COMBINED SEWER OVERFLOWS

Combined sewage is generated due to communities having only one set of sewers for both stormwater and sanitary sewage. This subject is addressed in Chapter 5. During and after rainstorms, combined sewage may exceed the capacity of conveyance and/or treatment facilities and is discharged close to its source. This is the cause of much of the identified pollution of Boston Harbor.

Combined sewer overflow correction is in Category V of the 1976 Needs Survey. The following types occur in the Study Area.

a. Untreated. Most backup of combined sewage overflows and is discharged to the nearest watercourse with no treatment whatsoever. This situation is not limited to communities having combined sewers and it also occurs in towns having sanitary sewers with inadequate peak capacity or inadequate capacity in regional systems.

b. Treated Combined Sewage. The treatment of combined sewage is not yet defined. As used here it pertains to effluents from facilities wherein the combined sewage has been

(1) screened and chlorinated prior to discharge, or

(2) screened, chlorinated and detained prior to discharge, or

(3) detained prior to discharge on the ebb tide.

E. SUMMARY OF CHAPTER 1

1. For over two hundred years (from 1630 to 1833) wastes were disposed of on land in dry privies; drains were used only for stormwater. The year 1833 was the beginning of a 119 year era in Boston when untreated wastes were transferred from land to the rivers and Boston Harbor. The first and second large treatment plants for the Boston area became operational in 1952 and 1968.

2. For over one-hundred years, Boston was among the leading cities in the nation in public health and sanitary engineering. The Metropolitan Sewerage District was the first regional wastewater authority in the United States. The MSD now provides treatment service to its 43 member communities while the local cities and towns operate their own collection sewer systems.

3. A wide range of types of municipal wastewaters create pollutional loadings on the rivers and Boston Harbor. These loadings vary from continuous and intermittent discharges of raw untreated sewage to effluents from primary, secondary and tertiary treatment plants. Sludge and scum solids are in some cases also discharged with the effluents. In addition, overflows from combined sewer systems frequently occur, most with little or no treatment. By 1962 there were fourteen municipal wastewater treatment plants. Today there are twenty in operation, plus one which has land disposal. They include municipal plants providing one or more sewered communities with a wide range of degree of treatment and three combined sewage plants that treat only a part of the wastewater part of the time.

4. Countless studies have been made and reports too numerous to mention have been published on Boston's wastewater problems. Adequate viable

and alternative solutions to pollutional problems have been proposed over the years. Major constraints in the past have been caused by lack of financing, while more-recently the moving target of government regulations and need for compliance with conflicting policies have contributed to the slowdown in plan implementation.

5. From the beginning of the Clean Water Grant Program through Fiscal year 1976, there have been more funds available than eligible certified projects in Massachusetts.* In Fiscal year 1977 the number and cost of otherwise eligible projects exceeds the remaining grant funds available.

6. The Areawide Waste Treatment Management Plan being conducted by MAPC pursuant to Section 208 of Public Law 92-500 will be completed after presently allotted grant funds available under Section 201 have been obligated.

7. The City of Boston started a precedent of allowing house sewers to be connected to storm drains in the year 1833. In retrospect, had the decision been made to build separate sewers, as was done in many other early communities, there would now be no issues regarding the combined sewer overflow problems which confront the study area today.

---

* (EPA advises that annual allotments were always obligated however.)

REFERENCES

1.1 Boston 200
Various Publications for the Bicentennial, 1976.

1.2 Erastus Washington
Historial Sketch of Mother Brook, Dedham, Mass.
Press of C. G. Wheeler, 1900.

1.3 J. Michael LaNier
"Historical Development of Municipal Water Systems in the United States"
Journal AWWA, April 1976.

1.4 Camp, Dresser & McKee/City of Boston
"Report on Improvements to the Boston Main Drainage System" (2 Volumes)
HUD Project No. P-MASS-3306, September 1967.

1.5 Cotton Mather
The Angel of Bethesda
1724.

1.6 Nathaniel Bradlee
The History of the Introduction of Pure Water into the City of Boston
Alfred Mudge & Son, Boston, 1868.

1.7 Lemuel Shattuck, Nathaniel P. Banks & Jehiel Abbott
"Report of the Sanitary Commission of Massachusetts"
April 25, 1850.

1.8 Laura Wood Roper
F L O: A Biography of Frederick Law Olmsted
Johns Hopkins University Press, 1973.

1.9 E. C. Clark
"Main Drainage Works of the City of Boston"
1885.

1.10 Harrison P. Eddy
"Historical Review of the Development of Sanitary Engineering in the United States"
Sewage Works Journal, February 1928.

1.11 Metropolitan Sewerage Commissioners
"Main Drainage Works of Boston and Its Metropolitan Sewerage District"
1899.

1.12 Hiram Mills, Chairman, State Board of Health
"Report of the State Board of Health Upon the Discharge of Sewage into Boston Harbor"
April 30, 1900.

1.13 Commonwealth of Massachusetts
"Report of Special Commission Relative to the Discharge of Sewage into Boston Harbor under Chapter 29, Resolves of 1929
Senate Document 56, December 3, 1930.

1.14 H. W. Streeter, Commenting on
"Assessing Damages for Sewage Pollution of Rivers"
Sewage Works Journal, Page 348, March 1934.

1.15 Commonwealth of Massachusetts
"Report of the Special Commission on the Investigation of the Discharge into Boston Harbor and Its Tributaries"
House Document 1600, December 1936.

1.16 Metcalf & Eddy and Greeley & Hanson
"Special Commission Investigating Systems of Sewerage and Sewage Disposal in the North and South Metropolitan Sewerage Districts and The City of Boston"
House Document 2465, June 15, 1939.

1.17 Arthur D. Weston and Gail P. Edwards
"Pollution of Boston Harbor"
Transactions of the ASCE, 1940, page 973.

1.18 Metcalf & Eddy and Greeley & Hansen
"Sewerage and Sewage Disposal Studies Under Chapter 512 of 1939,
General Design Drawings and Final Report"
January 1, 1941.

1.19 Karl R. Kennison
"(Nut Island) Disposal Plant to Alleviate Boston Harbor Nuisance" and "Problems of Solids Disposal Solved"
Civil Engineering June and July 1946.

1.20 Jack E. McKee/Camp, Dresser & McKee
"Loss of Sanitary Sewage through Storm Water Overflows"
Journal of the Boston S.C.E., Vol. 32, No. 2
March 5, 1947.

1.21 Metropolitan District Commission
Sewerage Division
"Annual Reports"
Published annually for Fiscal Years ending June 30.

1.22 Thomas R. Camp
"Realistic Appraisals Must Be Made of Values of Uses of Receiving Waters"
Sewage and Industrial Wastes Journal, April 1959.

1.23 U.S. Public Health Service
"Inventory of Municipal Waste Treatment Facilities as of 1962"
1965.

1.24 Metropolitan Area Planning Council
"Regionalism in Action MAPC 1976"
1976.

1.25 Clair N. Sawyer/Metcalf & Eddy
"The Sea Lettuce Problem in Boston Harbor"
Journal Water Pollution Control Federation Vol. 37, pp 1122,
August 1965.

1.26 Camp, Dresser & McKee/MAPC & DCD
"Inventory of Water and Sewer Facilities"
May 1967.

1.27 U.S. Environmental Protection Agency
"1968 Inventory of Municipal Waste Facilities"
1971.

1.28 Camp Dresser & McKee/MAPC & MDC
"Projected Needs and Current Proposals for Water and Sewer Facilities"
July 1969.

1.29 Sabin M. Lord, et al
"Boston Harbor Pollution Survey - 1968"
August 1970.

1.30 New England River Basins Commission
"Progress Towards Achieving Water Quality Goals for Boston Harbor"
October 22, 1970.

1.31 EPA Region I for New England River Basins Commission
"Interim Report on Combined Sewer Overflows in Boston Harbor"
Citation CW-10b, October 13, 1971.

1.32 EPA
"Proceedings, Third Session, Conference in the Matter of Pollution of the Navigable Waters of Boston Harbor and Its Tributaries"
October 27, 1971.

1.33 Camp Dresser & McKee/DWPC
"Water Quality Improvement of Tenean and Malibu Beaches"
CDM 448-5-RT, November 30, 1972.

1.34 Process Research, Inc./DWPC
"Combined Sewer Overflows to the Charles River Basin"
August 7, 1972.

1.35 Camp Dresser & McKee/MAPC
"Alternative Regional Sewerage Systems for the Boston Metropolitan Area"
HUD No. MASS P-135, October 1972.

1.36 C. E. Mcguire, Inc/DWPC
"Report on Water Quality Improvement of the Boston Back Bay Fens"
DWPC #72-06, May 1973.

1.37 Havens & Emerson Ltd/MDC
"A Plan for Sludge Management"
C250-313-01, August 30, 1973.

1.38 Camp, Dresser & McKee/City of Somerville
"Improvements to the Sewer System"
April 30, 1974.

1.39 Commonwealth of Massachusetts, DWPC
"Rules and Regulations for the Establishment of Minimum Water Quality Standards and for the Protection of the Quality and Value of Water Resources"
ZM-9-74-105926, May 13, 1974.

1.40 Havens and Emerson/MDC
"Environmental Assessment Statement for A Plan For Sludge Management"
October 1974.

1.41 Process Research, Inc./MDC
"Study of Pollution Control Alternatives for Dorchester Bay"
March 20, 1975.

1.42 Camp, Dresser & McKee/City of Boston
"1975 Supplement to 1967 Report (Reference 1.4) on Improvements to the Boston Main Drainage System (Facilities Plan)"
November 1975, Revised March 30, 1976.

1.43 Shoenfeld Associates/Boston Redevelopment Agency
"Environmental Assessment for Boston Downtown Waterfront Faneuil Hall Project"
December 3, 1975.

1.44 U.S. Environmental Protection Agency
"Cost Estimates for Construction of Publicly-owned Wastewater Treatment Facilities"
Final Report to the Congress February 10, 1975
Revised March 6, 1976.

1.45 Water Quality Section, Massachusetts DWPC
"Classification and Segmentation of Massachusetts River Basins and Coastal Zones - 1976"
Westborough, Massachusetts May 1976
Publication No. 8933-223-100-5-76-CR.

1.46 EPA, Region I and Mass. DPWC
"Discharge Permit (NPDES) for Metropolitan District Commission, Federal Permit No. MA 0102351, State Permit No. M 180"
Application January 15, 1974
Draft Permit January 9, 1976
Public Notice January 14, 1976
Final Permit August 12, 1976
ECSL August 11, 1976.

1.47 Metcalf & Eddy, Inc./MDC
"Wastewater Engineering and Management Plan for Boston Harbor-Eastern Massachusetts Metropolitan Area - EMMA Study"
Main Report and Summary: March 1976
Appendices dated October 1975
(Released June 1976)

1.47 Continued

INDEX TO EMMA STUDY REPORTS

BROCHURE

SUMMARY REPORT

MAIN REPORT

TECHNICAL DATA VOLUMES

1	PLANNING CRITERIA
2	ENGINEERING CRITERIA
3	INDUSTRIAL PROCESS WASTEWATER ANALYSIS AND REGULATION
3A	STUDY OF CERTAIN INDUSTRIAL WASTES
3B	STUDY OF WASTES FROM LARGE INDUSTRIES
4	WATER ORIENTED WASTEWATER UTILIZATION CONCEPTS
5	LAND ORIENTED WASTEWATER UTILIZATION CONCEPTS
6	FORMULATION OF WASTEWATER UTILIZATION PLAN
7	COMBINED SEWER OVERFLOW REGULATION
8	URBAN STORMWATER MANAGEMENT
8A	APPENDIX TO URBAN STORMWATER MANAGEMENT
9	MDC INTERCEPTOR AND PUMPING STATION ANALYSIS AND IMPROVEMENTS
10	DEER ISLAND WASTEWATER TREATMENT PLANT ANALYSIS AND IMPROVEMENTS
11	NUT ISLAND WASTEWATER TREATMENT PLANT ANALYSIS AND IMPROVEMENTS
12	FINANCING AND MANAGEMENT
13	IMPACT ANALYSIS AND EVALUATION
13A	BIOLOGICAL IMPACT ANALYSIS
13B	SOCIO-ECONOMIC IMPACT ANALYSIS
13C	HYGIENIC IMPACT ANALYSIS
13D	VISUAL, CULTURAL AND DESIGN IMPACT ANALYSIS
14	PUBLIC INVOLVEMENT
15	RECOMMENDED PLAN AND IMPLEMENTATION PROGRAM

1.48 Massachusetts DWPC
"Anuual Program Plan for Fiscal Year 1977 (Project Priority List)"
Proposed List: August 19, 1976
Final List ____________1976.

1.49 MAPC
"208 (Project) Interim Output"
Preliminary Copy: May 10, 1976.

1.50 Mass. DWPC
"Part D Water Quality Management (Basin) Plan"
For Various Basins, 1975 or 1976.

1.51 MAPC
"Roster of Facilities and Sewer Service in MAPC Region"
1976.

1.52 EPA, Region I
"NPDES Facility Listing"
(Selected and sorted for the Study Area)
Printout dated July 29, 1976.

1.53 Board of Certification of Operators of Wastewater Treatment Facilities, Robert C. McAnespie, Executive Secretary Commonwealth of Massachusetts, Division of Registration
"Classification of Wastewater Treatment Plants"
November 8, 1976.

1.54 Ibid.
"Wastewater Treatment Plant Operators Holding Massachusetts Grades 5, 6 and 7 Certificates"
September 3, 1976.

Contents

Chapter 2

DEER AND NUT ISLAND TREATMENT PLANTS

Section — Page

A. DEER ISLAND SEWAGE TREATMENT PLANT 2.2
  1. General Description 2.2
  2. Discharge Requirements 2.13
  3. Efficiency of Treatment at Deer Island 2.16
  4. Kennedy Engineers' Observations of Facilities 2.33
  5. Tunnel Headworks 2.46
  6. Joint Task Force Observations of Deer Island 2.47
  7. EMMA Plan to Improve Primary Treatment at Deer Island 2.59

B. NUT ISLAND SEWAGE TREATMENT PLANT 2.65
  1. General Description 2.65
  2. Discharge Requirements 2.75
  3. Efficiency of Treatment at Nut Island 2.77
  4. Kennedy Engineers' Observations of Facilities 2.95
  5. Joint Task Force Observations of Nut Island 2.105
  6. EMMA Plan to Improve Primary Treatment at Nut Island 2.117

C. COSTS 2.122

D. OPERATIONS AND MAINTENANCE PRACTICES 2.127
  1. Existing Training Programs, Manuals and Certification Programs 2.127
  2. Recommended Improvements 2.130
  3. Recommendations 2.132

E. SUMMARY OF CHAPTER 2 2.134

REFERENCES 2.143

Contents of Chapter 2, Continued

Figures and Tables

Page

Figure 2-1 MSD Treatment Plant Service Areas 2.3
2-2 Deer Island Flow Diagram 2.6
2-3 Deer Island Sed. Tank Characteristics 2.21
2-4 Deer Island Treatment Efficiencies 2.24
2-5 Nut Island Flow Diagram 2.68
2-6 Nut Island Sed. Tank Characteristics 2.81
2-7 Nut Island Treatment Efficiencies 2.85
2-8 Treatment Plant Construction Costs 2.123

Table 2-1 Deer Island Plant Performance 2.17
2-2 Deer Island Sed. Tanks in Service 2.20
2-3 Deer Island Sludge and Scum Characteristics 2.26
2-4 Deer Island Annual Performance Comparison 2.30
2-5 Deer Island Permit Compliance 2.32
2-6 Basic Design Criteria - Deer Island Expansion 2.61
2-7 Nut Island Plant Performance 2.80
2-8 Nut Island Sed. Tanks in Service 2.82
2-9 Nut Island Sludge Characteristics 2.87
2-10 Nut Island BOD Removal Efficiency 2.89
2-11 Nut Island Solids Removal Efficiency 2.90
2-12 Nut Island Annual Performance Comparison 2.93
2-13 Nut Island Permit Compliance 2.96
2-14 Basic Design Criteria - Nut Island Expansion 2.118

CHAPTER 2

DEER AND NUT ISLAND TREATMENT PLANTS

This Chapter reports on Kennedy Engineers' examination of the two existing sewage treatment plants of the Metropolitan Sewerage District. The first part will analyze the Deer Island facility and the second part of the chapter will concentrate on the Nut Island Treatment Plant. A physical description of each facility along with a discussion of the service area will be followed by an analysis of the treatment performance of the respective plants. This will be followed by observations on the physical conditions and laboratory procedures at the treatment plants.

This Chapter includes a discussion of the operation and maintenance practices presently employed by the Metropolitan District Commission and how such practices relate to the treatment capability at the Deer and Nut Island plants. In addition, the future plans for the two facilities as detailed in the EMMA Recommended Plan will be examined. Interim improvements that could be employed to improve performance will be discussed.

It is realized that both the Deer and Nut Island Treatment Plants were planned and constructed prior to the passage of PL 92-500. Consequently, the facilities were not designed to meet requirements of the Act or the new NPDES permit. The purpose of this Chapter, therefore, is to objectively evaluate the two treatment facilities, the reliability and the level of treatment.

Excluded is a detailed analysis of sludge management, as that topic is the subject of a parallel study by another consultant to the National Science Foundation. Adequacy of existing and proposed interceptors have not been reviewed in this study.

A. DEER ISLAND SEWAGE TREATMENT PLANT

1. General Description.

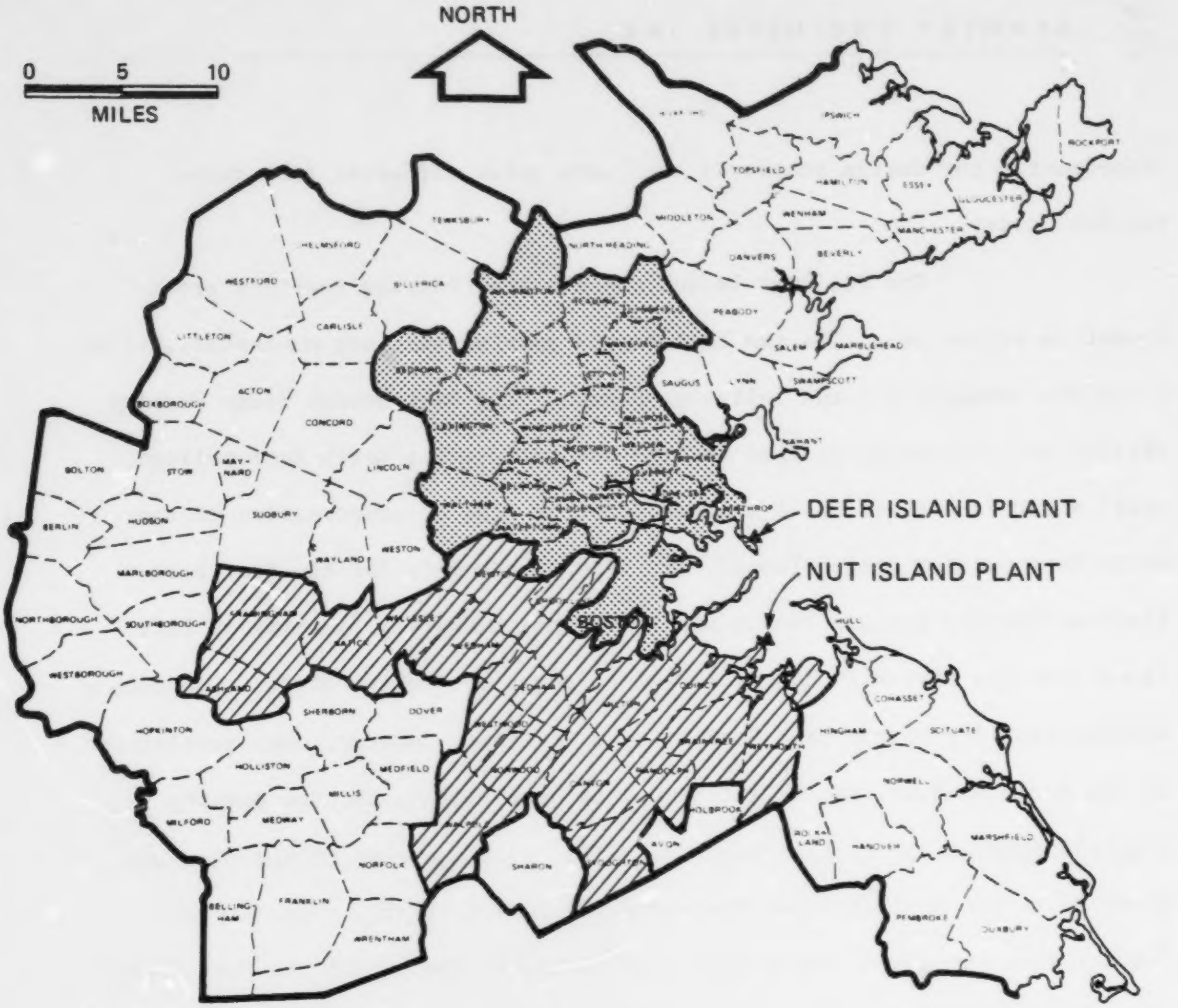
The Deer Island Sewage Treatment Plant is situated on a stretch of land which formerly was an island located in the northern portion of Boston Harbor east of Logan International Airport. The treatment facility has been in operation since June 1968, and it presently serves twenty-two communities as well as portions of Boston, Brookline, Newton and Milton as shown on Figure 2-1. The combined service area is 168 square miles, and the total population served is approximately 1.4 million people, reference 2.1.

The treatment plant is reported to have been designed to provide primary treatment for an average daily flow of 343 million gallons per day (mgd). It has a design peak hydraulic capacity of 848 mgd.

a. The Northern Metropolitan System Pumping Stations. The following seven MDC pumping stations are in the Deer Island service area (North Metropolitan System):

PUMPING STATION	RATED CAPACITY (mgd)
Alewife Brook	90.6
Charlestown	140
East Boston Electric	125
East Boston Steam	205
Reading	8
Old Deer Island	(abandoned)
Old Winthrop Pumping Station	(abandoned)

There are also two active pump stations at the Deer Island plant, Deer Island Main Pumping Station and the Winthrop Terminal. Of the five active remote pumping stations, all except Alewife Brook are over 25 years old.



NORTH
0
5
10
MILES
DEER ISLAND PLANT
NUT ISLAND PLANT
IPSWICH
ROCKPORT
TOPSFIELD
HAMILTON
ESSEX
GLOUCESTER
MIDDLETON
WENHAM
MANCHESTER
DANVERS
BEVERLY
TEWKSBURY
NORTH READING
CHELMSFORD
WESTFORD
BILLERICA
PEABODY
LITTLETON
CARLISLE
SALEM
MARBLEHEAD
SAUGUS
LYNN
SWAMPSCOTT
BOXBOROUGH
ACTON
CONCORD
NAHANT
BOLTON
STOW
MAY-NARD
LINCOLN
BERLIN
HUDSON
SUDBURY
WINTHROP
WESTON
WAYLAND
MARLBOROUGH
NORTHBOROUGH
SOUTHBOROUGH
FRAMINGHAM
NATICK
WELLESLEY
NEEDHAM
BOSTON
HULL
WESTBOROUGH
ASHLAND
SHERBORN
DOVER
DEDHAM
QUINCY
COHASSET
HOPKINTON
WESTWOOD
HINGHAM
SCITUATE
BRAINTREE
WEYMOUTH
HOLLISTON
MEDFIELD
NORWOOD
CANTON
RANDOLPH
NORWELL
MILLIS
MILFORD
MEDWAY
WALPOLE
HOLBROOK
ROCKLAND
HANOVER
MARSHFIELD
NORFOLK
SHARON
STOUGHTON
AVON
BELLING-HAM
FRANKLIN
PEMBROKE
DUXBURY
WRENTHAM

LEGEND

▨ DEER ISLAND SERVICE AREA

▨ NUT ISLAND SERVICE AREA

NSF Boston Case Study, Phase II Evaluation

MSD TREATMENT PLANT
SERVICE AREAS

Kennedy Engineers, Inc.
1977

Figure **2·1**

Basemap: EMMA Report

Consequently the design standards used were quite different from those required today.

The Old Deer Island and Winthrop Pumping Stations are no longer in active use. The two East Boston pumping stations are essentially in a standby category for the following reason. The East Boston Steam Pumping Station was originally planned to lift sewage into the North Metropolitan Sewer after it crossed Chelsea Creek. At the time of construction of the North Metropolitan Relief Tunnel, provisions were made for the East Boston Electric Pumping Station (which was built as a temporary facility to lift flows from the partially completed relief sewer to Chelsea Creek) to become a standby facility to the East Boston Steam Station. However, upon completion of the North Metropolitan Relief Tunnel to Deer Island, the two pumping stations essentially became stand-by facilities since most of the flow was diverted to the Chelsea Creek Headworks (discussed later). The only dry weather flow pumped, during normal conditions, is that which the East Boston Steam Pumping Station transmits from the Orient Heights and East Boston Sewers to the North Metropolitan Trunk Sewer.

The standby capability of the two facilities can be used when the Main Pumping Station at Deer Island cannot handle the flow in the North Metropolitan Relief Tunnel. This inadequate pumping capability at Deer Island can be due to mechanical difficulties, power failures, labor problems or simply to excessive wet-weather flow. Under these conditions, the Chelsea Creek Headworks can divert a portion of the flow to the two East Boston Pumping Stations. The East Boston pump stations can discharge to Deer Island through the North Metropolitan Trunk Sewer and Winthrop Terminal, or can overflow directly to Chelsea Creek when the Deer Island pumping capacity is exceeded.

b. The headworks of Deer Island. Four headworks pretreat the sewage before it reaches the sedimentation tanks at Deer Island as shown on Figure 2-2. Three of the headworks are located remote from Deer Island, while the Winthrop Terminal Facility is on the island itself. The four headworks, reference 2.2, with their peak design capacities are:

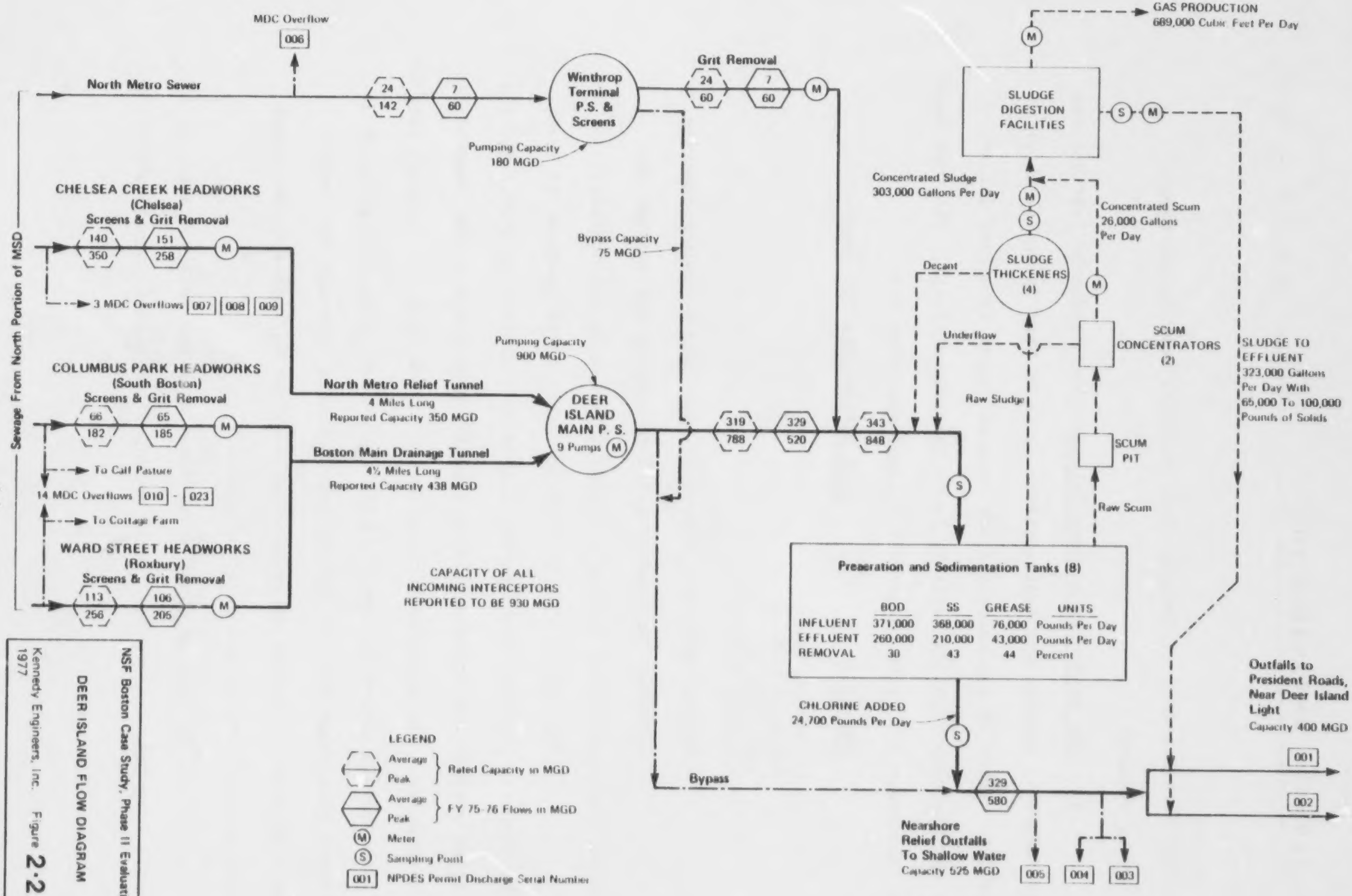
FACILITY	PEAK DESIGN CAPACITY (mgd)
Chelsea Creek	350*
Columbus Park	182*
Ward Street	256*
Winthrop Terminal	135

* Actual peaks are limited by Deer Island pumping capacity.

Winthrop Terminal is rated to pump 60 mgd through the treatment plant and 75 mgd through a bypass directly to the outfalls.

The three off-site headworks were first operated in 1968, and the Winthrop Terminal Facility was placed in operation in 1970. All the facilities provide bar screens (3/4 inch clear openings) and grit removal for the wastewaters. The Columbus Park, Ward Street and Winthrop Terminal facilities also contain coarse bar racks (3-1/2 inch clear openings), although it is planned that these will be removed from Columbus Park and Ward Street. During high flows, floating material flows over the bar screens and causes problems in grit removal and plant operation.

The Chelsea Creek Headworks discharges into the shaft of a four-mile long deep rock tunnel (North Metropolitan Relief Tunnel) which


MDC Overflow
006
North Metro Sewer
24
142
7
60
Winthrop Terminal P.S. & Screens
Pumping Capacity 180 MGD
Grit Removal
24
60
7
60
M
GAS PRODUCTION
689,000 Cubic Feet Per Day
M
SLUDGE DIGESTION FACILITIES
S
M
Concentrated Sludge
303,000 Gallons Per Day
Concentrated Scum
26,000 Gallons Per Day
Sewage From North Portion of MSD
CHELSEA CREEK HEADWORKS
(Chelsea)
Screens & Grit Removal
140
350
151
258
M
3 MDC Overflows 007 008 009
Bypass Capacity 75 MGD
Decant
SLUDGE THICKENERS (4)
Underflow
SCUM CONCENTRATORS (2)
SLUDGE TO EFFLUENT
323,000 Gallons Per Day With 65,000 To 100,000 Pounds of Solids
Raw Sludge
COLUMBUS PARK HEADWORKS
(South Boston)
Screens & Grit Removal
66
182
65
185
M
Pumping Capacity 900 MGD
North Metro Relief Tunnel
4 Miles Long
Reported Capacity 350 MGD
DEER ISLAND MAIN P. S.
9 Pumps M
319
788
329
520
343
848
SCUM PIT
Boston Main Drainage Tunnel
4½ Miles Long
Reported Capacity 438 MGD
To Calf Pasture
14 MDC Overflows 010 - 023
To Cottage Farm
Raw Scum
WARD STREET HEADWORKS
(Roxbury)
Screens & Grit Removal
113
256
106
205
M
CAPACITY OF ALL INCOMING INTERCEPTORS REPORTED TO BE 930 MGD
Preaeration and Sedimentation Tanks (8)
BOD SS GREASE UNITS
INFLUENT 371,000 368,000 76,000 Pounds Per Day
EFFLUENT 260,000 210,000 43,000 Pounds Per Day
REMOVAL 30 43 44 Percent
Outfalls to President Roads, Near Deer Island Light
Capacity 400 MGD
CHLORINE ADDED
24,700 Pounds Per Day
S
001
002
Bypass
329
580
Nearshore Relief Outfalls To Shallow Water
Capacity 525 MGD
005
004
003
LEGEND
Average
Peak
Rated Capacity in MGD
Average
Peak
FY 75-76 Flows in MGD
M Meter
S Sampling Point
001 NPDES Permit Discharge Serial Number

NSF Boston Case Study, Phase II Evaluation

DEER ISLAND FLOW DIAGRAM

Kennedy Engineers, Inc. Figure **2·2**
1977

carries the flow under the Harbor to the Deer Island main pumping station. The Columbus Park and Ward Street headworks discharge to a seven-mile long deep rock tunnel (Boston Main Drainage Tunnel) which leads to the same main pumping station. The tunnels are about 300 feet deep.

The flow entering Winthrop Terminal is first screened and then pumped directly to a Parshall flume. Flow is then by gravity through aerated grit chambers to the treatment plant. Although original pumping capacity was 60 mgd, increase in capacity to 180 mgd has been installed. However, all flows in excess of 60 mgd must be diverted to the plant bypass due to restriction in grit chamber capacity, references 2.1 and 2.2. These pumps normally discharge to the plant grit chambers, but can be diverted to the treatment plant bypass when necessary.

c. Unit processes at Deer Island.

(1) Main pumping station. The main pumping station has design capacity of 900 mgd with all pumps operating with 9 mixed flow, centrifugal sewage pumps. These pumps are operated by nine 12-cylinder, two-cycle radial, dual-fuel type engines, references 2.1, 2.3, and 2.4. It is probable that the present continuous pumping capacity is less than half the design capacity due to pump deterioration and problems with the engines and drive shafts, requiring frequent raw sewage bypass. These problems will be discussed later. Each of the pumps may handle the flow from either one of the deep rock tunnels into Deer Island but not both at the same time.

(2) Power generation and distribution. The Deer Island facility produces power by five dual-fuel diesel engine driven alternators,

rated at 4160 volts, 700 KW, 875 KVA each. A minimum of ten percent of the fuel burned is diesel pilot fuel, while the remainder is digester gas. The five generators provide all of the electrical energy for the plant. The power is distributed to five outdoor substations by the station's High Voltage Switchgear.

(3) Control system. Control of the influent pumping at Deer Island is necessary to balance the flows into and out of the long deep rock tunnels. The system was designed with automatic control of the pumping rate which was adjusted to maintain a set water level in each shaft at Deer Island and in the three headworks. Communications from each of the headworks to Deer Island are performed using microwaves although a telephone line service is avilable for back-up in the event of microwave interruption (most often due to low flying aircraft). The control center is manned 24-hours a day. Due to the number of pumps out of service, pump control is now semi-automatic with raw sewage diverted ahead of the headworks facilities when capacity is exceeded.

When inadequate pump capacity is available to handle the flow from the tunnels, the operator at Deer Island notifies the headworks to throttle headworks influent gates, causing raw sewage overflows. Even if all the engines were working at full speed it appears that bypass would still be necessary when the wet weather flow at the headworks exceeds about 900 mgd.

In the event of the throttling of the flow at Ward Street, the collector sewers and interceptors leading to the facility back up and require the activation of the Cottage Farm Chlorination and Detention

Station (described in Chapter 5), with discharge to the Charles River, which is a distance of approximately 1 1/2 miles from Ward Street.

When the flow at the Columbus Park Headworks is throttled the sewage backs up to the Calf Pasture Pumping Station (with possible overflows occurring along the way). The flow is then pumped to Moon Island for storage and subsequent release to the Harbor at ebb tide. Both Calf Pasture and Moon Island are circa 1878 facilities owned and operated by the City of Boston. Additional instrumentation exists for in-plant control. These include flow meters, ammeters and tachometers (for indications of sludge pump output), pressure sensor meters (on sludge pumps), scum flow meters, gas meters and temperature sensors (for the digestors), and chlorine metering.

(4) Pre-aeration. The flows from the main pumping station combine with that from the Winthrop Terminal and then are split between two pre-aeration channels. Each channel is 400 feet long, 20 feet wide and 14 feet deep which provides a detention time of 7 minutes at average daily design flow. Forty-four swing air diffusers provide 0.02 cubic feet of air per gallon of sewage when the flow is 343 mgd.

(5) Sedimentation. Each of the eight sedimentation tanks at Deer Island is 245 feet long, 100 feet wide and 10 feet deep. At average daily design flow, detention time in the tanks is 60 minutes and the overflow rate is 1750 GPD/square foot.

Settled solids (sludge) and scum are collected by traveling bridge collectors with chain cross-collectors. The scum is pushed to the downstream end of the tank where the cross-collectors return the floated solids to a collection pit for subsequent pumping to scum concentration tanks. The bridge then transports the sludge to the upstream end of the tank from where the sludge is pumped to the thickeners.

Sludge pumping from the sedimentation tanks is achieved with four pumping stations (one for each pair of sedimentation tanks). Each station contains three high rate variable speed torque-flow pumps which operate on a staggered basis, each pump operating for four hours at a time.

(6) Chlorination. Both pre- and post-chlorination is available at Deer Island, although only post-chlorination is performed routinely. Pre-chlorination is only practiced for odor control or if a breakdown occurs in the post-chlorination system.

Seven chlorinators having a capacity of 8000 lbs/day and one with a capacity of 2000 lbs/day are installed for manual chlorination operation. An average of 12.3 milligrams per liter (mg/l) of chlorine is applied in the primary effluent channel. There is now inadequate chlorine solution diffusion and mixing. At this dosage rate, which is based on maintaining a chlorine residual of 1 mg/l after 15 minutes of contact, the total capacity of the chlorinators has capacity to treat the average daily design flow. It is not adequate for the peak day flow. One chlorinator can also be used to serve the Winthrop Terminal Facility in the event of a bypass.

Seven chlorine evaporators are installed at the facility. Each chlorinator has its own injector to which reclaimed plant water is supplied at a pressure of 40 pounds per square inch. Chlorine is delivered and fed from 16-ton mobile containers.

(7) Scum and sludge thickening. The scum from the sedimentation tanks is pumped to the two scum concentrators by two raw scum pumps. Each concentrator is 26 feet by 12 feet with a depth of 8.5 feet. The total capacity of each tank is almost 20,000 gallons. Two other 1000 gpm centrifugal pumps transfer the concentrated scum to the digesters.

Each of the four circular sludge thickening tanks is 55 feet in diameter and nine feet deep (excluding sludge hopper and freeboard depths). Rotating scraper blades deposit the sludge in a center hopper. The thickened sludge is pumped to the digesters by the two-100 gpm positive displacement plunger pumps available for each thickener. The operators try to maintain a thickened sludge having a five percent solids content at all times. The overflow from the thickeners is returned to the head end of the treatment plant.

(8) Anaerobic digestion. Pumping of sludge and scum into the digesters occurs intermittently throughout the day. Three of the four digesters are now used for primary digestion, while the fourth is used as a holding tank. Each digester has a gross capacity of 2.13 million gallons, and is 108 feet in diameter and 30 feet in depth (exclusive of sludge hopper and freeboard).

The primary digesters have fixed covers, continuous recirculation of the contents using draft tubes mixers, and are heated by external heat exchangers. The digester used as a storage tank also has a fixed cover, but no recirculation or heating is performed.

The four heat exchangers for the digesters are external spiral type heat exchangers. The heat is distributed by the recirculation of engine jacket water. The heated sludge goes to the thickener area for blending with the undigested sludge prior to addition to the digesters. The primary digesters are maintained at a temperature of approximately 98°F.

Each of the digesters makes use of two pumps for recirculation through the heat exchangers, and the holding tank has a third pump for pumping the digested sludge to sea. The sludge is discharged through one of the same deep water outfalls as the plant effluent, and is released during the outgoing tide.

Gas is drawn from all four digesters and is compressed by four compressors. Storage is in a 60 foot diameter sphere at a pressure of 40 pounds per square inch. Excess gas is wasted through burners on the roof of the digester building.

Large amounts of scum accumulates in the digestion tanks at Deer Island. Because cutting oils and other mineral oils and cellulose products such as paper and cigarette filters as well as plastics are not amenable to digestion, consideration should be given to incinerator or other separate disposal of oils and other scum removed.

At the time of site visit it was reported that about one-third of digestion capacity was taken up by scum and one third by grit. This indicates that investigation should be made as to the efficiency of removal in grit basins. Both quantity and gradation should be determined. In addition, the character of grit that escapes (i.e. accumulates in digesters) should be determined. Modifications to improve grit removal efficiency may be indicated.

(9) Outfall system. Two main outfalls from Deer Island terminate in President Roads in Boston Harbor, at a depth of approximately 50 feet below mean low water. One outfall is 9 feet by 10 feet, while the other is 6 feet by 1 1/2 feet. Three additional relief off-shore bypass outfalls (one 6-foot diameter and two 9-foot diameter pipes) also exist for use during storm flows in excess of 400, 500, and 600 mgd.

(10) Process water facility. A portion of the plant effluent is stored in a reservoir for use in chlorination and diesel engine cooling at the plant. The process water system and reservoir originally used salt water, but conversion to plant effluent was done to reduce the maintenance due to corrosion caused by salt water.

2. DISCHARGE REQUIREMENTS

Effluent restrictions and monitoring requirements for the Deer Island Treatment Plant are included in the National Pollutant Discharge Elimination System (NPDES) permit No. MA 0102351 issued to the Metropolitan District Commission, on August 12, 1976. Effluent limitations are presented in two categories; those applying until June 30, 1977, and those that the Deer Island facility must comply with after that date. The date was extended until October 1, 1984 by the enforcement compliance schedule letter. For the purposes of this Chapter, we will present the requirements of the NPDES permit that presently apply to the treatment plant, reference 2.5

a. Effluent limits.

(1) The Deer Island facility is authorized to discharge from the two main plant outfalls (Serial Nos. 001 and 002):

> "...an effluent to Boston Harbor whose concentration and combined loading (excluding digested sludge) shall not exceed the values listed below:

Effluent Characteristic	Monthly Average	Weekly Average	Maximum Day
Flow, (mgd)	*		
Biochemical Oxygen Demand, 5-day, 20°C	474,000 lbs/day 140 mg/l	145 mg/l	200 mg/l
Total Suspended Solids	306,000 lbs/day 91 mg/l	94 mg/l	140 mg/l
Settleable Solids	-	-	1.5 ml/l
Fecal Coliform Bacteria	Provide continuous chlorination		
Total Coliform Bacteria	Provide continuous chlorination		

* For any consecutive 12 month period, the average quantity of effluent discharged shall not exceed 403 mgd."

The NPDES permit also includes the following requirements:

(a) The minimum percent removals of biochemical oxygen demand and total suspended solids shall be 26 percent and 42 percent, based on a twelve consecutive monthly average of influent and effluent concentrations of the two parameters:

(b) "The pH of the effluent shall not be less than 6.0 nor greater than 9.0 at any time unless these values are exceeded due to natural causes or as a result of the approved treatment processes."

(c) "The total chlorine residual of the effluent shall not result in any demonstrable harm to aquatic life or violate any water quality standard which has been or may be promulgated."

(d) "The discharge shall not cause visible discoloration of the receiving waters after appropriate mixing."

(e) "Until termination of the sludge discharge, digested sludge may be discharged from Discharge Serial Nos. 001 and 002 of the Deer Island facility to Boston Harbor only during the four-hour period beginning at high tide."

There are no effluent limitations on quality or quantity of sludge discharged from Deer Island.

(2) Until expiration of the permit (May 1, 1981), Deer Island may discharge chlorinated primary treated effluent from the three relief outfalls when the influent flow rate exceeds 400, 500, and 600 mgd. There is no numerical limitation on chlorine toxicity.

b. Monitoring and reporting requirements.

(1) The Deer Island plant is required to monitor and record the quality and quantity of the discharges from the two main plant outfalls without the sludge. BOD, suspended solids, and temperature of the influent must also be monitored. The NPDES permit enumerates the parameters to be measured, the minimum frequency of analyses, and the type of sample to be collected (grab sample vs. composite sample). "Daily" is defined in the permit as five days a week. "Weekly average" is defined as the average of three days of data and "Monthly average" is defined as the average of twelve days of data.

(2) When discharges occur from the relief outfalls of Deer Island, the flow in them is required to be measured.

(3) Although there are no limitations, requirements are specified for the monitoring and recording of the quality and quantity of

discharge of digested sludge. The parameters to be measured, the frequency of analysis, and the sample type to be obtained are all listed. The BOD of the sludge effluent is not required to be determined.

3. EFFICIENCY OF TREATMENT AT DEER ISLAND.

a. Performance during the period July, 1975 through June, 1976. The values reported in this section were obtained from monthly data sheets filled out by personnel at the Deer Island Treatment Plant, reference 2.6. Data for the Deer Island effluent were obtained for the period July, 1975 through June, 1976, excepting the month of September. Monthly data summarizing the performance of the anaerobic digesters were obtained for the same period, although the data for the months of September and March were missing.

Table 2-1 presents a summary of the efficiency of primary treatment at Deer Island for the MDC Fiscal Year 1975-76. The flows listed are average daily flows, and do not indicate the large diurnal fluctuations of sewage flow that occur due to peaks and tidal inflows. Thus the minimum and maximum flows shown for each month do not indicate the instantaneous flow rates but are only the smallest and largest average daily flows discharged to the plant during that respective month. The significant sewage flows tributary to the Deer Island plant that are diverted to overflows due to throttling at the headworks are also not measured. The average flows reported are the average of all the average daily flows for the month, as recorded on the referenced data sheets. Average annual effluent emissions in flows that pass through the treatment plant amounted to 260,000 pounds per day of

TABLE 2-1

PERFORMANCE AT DEER ISLAND PLANT

MONTH/YR	AVE. DAILY FLOW (MGD)			PERCENT REMOVALS (AVG. FOR MONTH)			AVERAGE DETENTION TIME (MINUTES)	AVERAGE SURFACE LOADING RATE (GPD/SF)
	MIN	MAX	AVG. FOR MONTH	SETTLEABLE SOLIDS	BOD_5	SUSPENDED SOLIDS		
7/75	244	366	278	88	32	46	69	1600
8/75	264	462	308	87	27	52	58	1800
10/75	202	460	333	74	24	38	47	2300
11/75	289	487	360	75	31	43	48	2300
12/75	276	495	340	81	33	48	53	2000
1/76	302	497	378	72	29	29	43	2500
2/76	306	414	348	74	28	32	39	2800
3/76	310	384	343	69	32	35	44	2500
4/76	289	367	321	78	29	45	58	1900
5/76	269	364	302	84	35	52	60	1800
6/76	263	316	287	86	29	50	62	1700
AVERAGE (11 months)	274	419	327	79	30	43	53	2100

BOD, 210,000 pounds per day of suspended solids, and 43,000 pounds per day of grease. The percentage removal of grease is 44, a figure considered low.

Bacterial concentrations were reported as Millipore Filter units per 100 milliter and were shown to have been reduced from 84 million in the influent to 700 in the treated effluent, exclusive of coliform levels in sludge discharged with effluent. While this is a reduction of 99.99 percent, the bacteria in the effluent still amounts to 8.6×10^{12} per day.

The effluent, when discharged, also is reported contain a chlorine residual of 0.4 milligrams per liter. This amounts to about 1100 pounds of chlorine per day in the discharge.*

The percent removals indicated on Table 2-1 are monthly averages as computed by MDC by averaging the total monthly influent and effluent concentrations of the parameter. A more representative evaluation of efficiency may usually be obtained if percent removals are based on total loadings (units of pounds per day) rather than on concentrations (units of milligrams per liter).

In order to compute the average monthly detention time and surface loading rate of the sewage in the sedimentation tanks, it was necessary to know the number of sedimentation tanks in operation at Deer Island during fiscal year 1975-76. Although we could not confirm the number of tanks operating each day, we were given the information in Table 2-2 from the Superintendent of Deer Island. Knowing the average number of tanks operating each month, and knowing the average daily flow for the month, we computed an average detention time and surface loading rate on this basis as shown

* (Chlorine is considered an undesirable toxicant in some areas.)

in Table 2-1.

Sedimentation tanks are normally designed on the basis of surface loading rate at the average rate of flow. The correlation between the surface loading rate and hydraulic detention time for a particular tank is dependent upon the size and geometry of the tank. The two curves in Figure 2-3 show this relationship for a single sedimentation tank at Deer Island. Performance will normally improve with decreasing overflow rates and with increasing detention times.

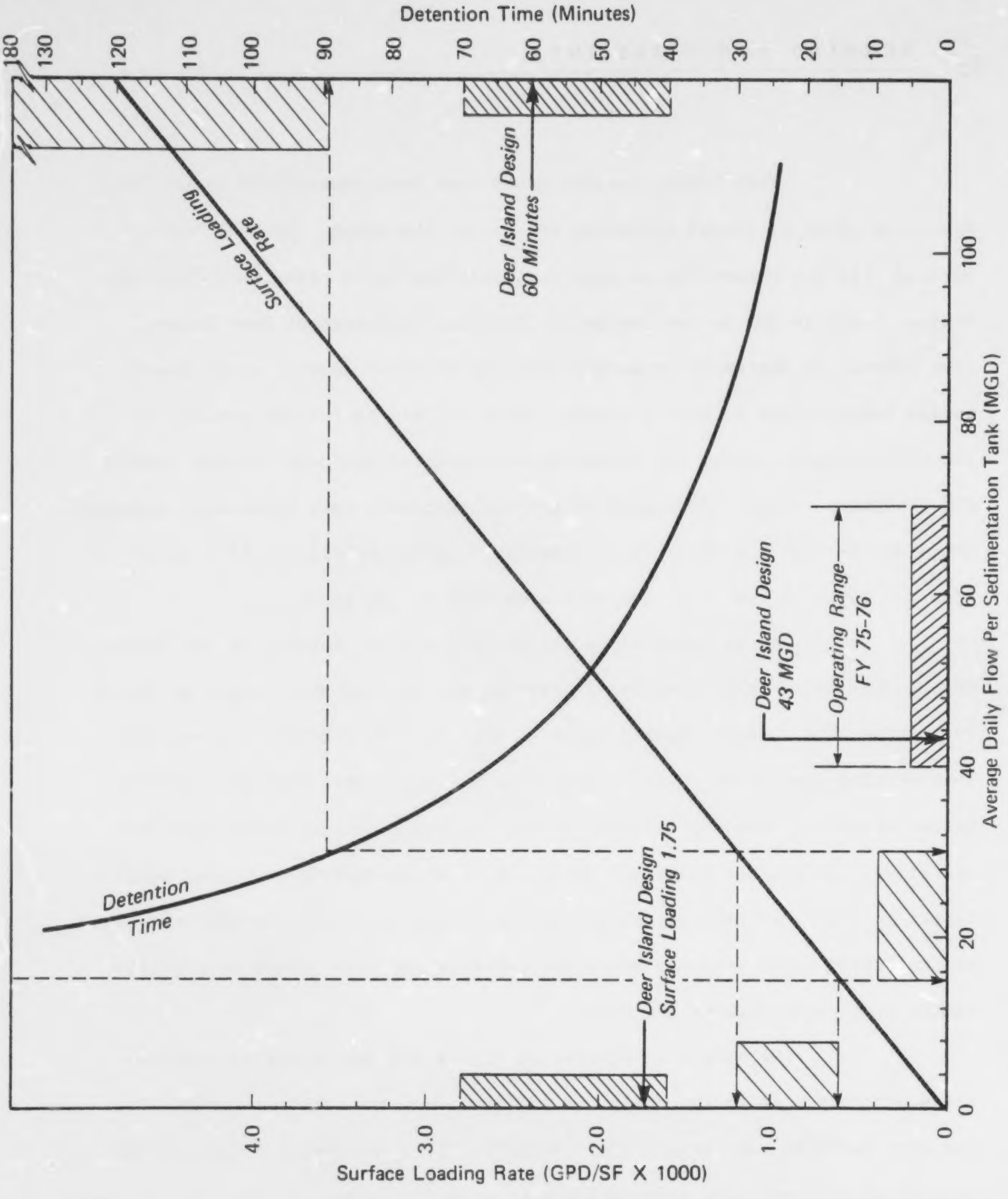
Displayed on Figure 2-3 are the surface loading rates, detention times and average daily flows per tank achieved at Deer Island during fiscal year 1975-76. It is also shown that the design detention time of 60 minutes corresponds to an overflow rate of 1750 gallons per day per square foot of surface area, and 43 million gallons per day of sewage per sedimentation tank. With all eight tanks in operation, the total rated design flow comes to approximately 343 mgd for eight tanks. Seldom are all eight tanks avaiable for service however.

For fiscal year 1975-76, Figure 2-3 shows that the range of average flow per tank usually exceeded the design flow. The reason for this is shown clearly by Table 2-2. While the average daily flow for the fiscal year was less than the design value of 343 mgd, all tanks were used only eleven percent of the time, and less than 7 tanks were in service half the time. With an average of 6 1/2 tanks in service during the year, the flow per tank was usually much higher than the 43 mgd design capacity.

TABLE 2-2

DEER ISLAND SEDIMENTATION TANKS IN SERVICE
(DAYS PER MONTH DURING FY 75-76)

	Tanks in Service						
MONTH	8 (ALL)	7	6	5	4		AVERAGE
JULY 1975	13	13	5				7.3
AUG	4	20	5	2			6.8
SEPT	0	24	6				6.8
OCT	0	4	20	7			5.9
NOV	2	16	7	5			6.5
DEC	8	11	11	1			6.8
JAN 1976	0	7	23	1			6.2
FEB	0	0	7	17	5		5.1
MAR	0	4	4	23			5.7
APR	9	9	12				7.1
MAY	3	21	7				6.9
JUNE	0	22	8				6.7
ANNUAL TOTAL:	39	151	115	56	5	Σ 366	6.5
% OF TOTAL:	11	41	31	15	1		



▨ Values Realized at Deer Island (Ref. 2.6)

▨ Typical Design Values (Ref. 2.7)

NSF Boston Case Study, Phase II Evaluation

DEER ISLAND SEDIMENTATION TANK CHARACTERISTICS

Kennedy Engineers, Inc.
1977

Figure **2·3**

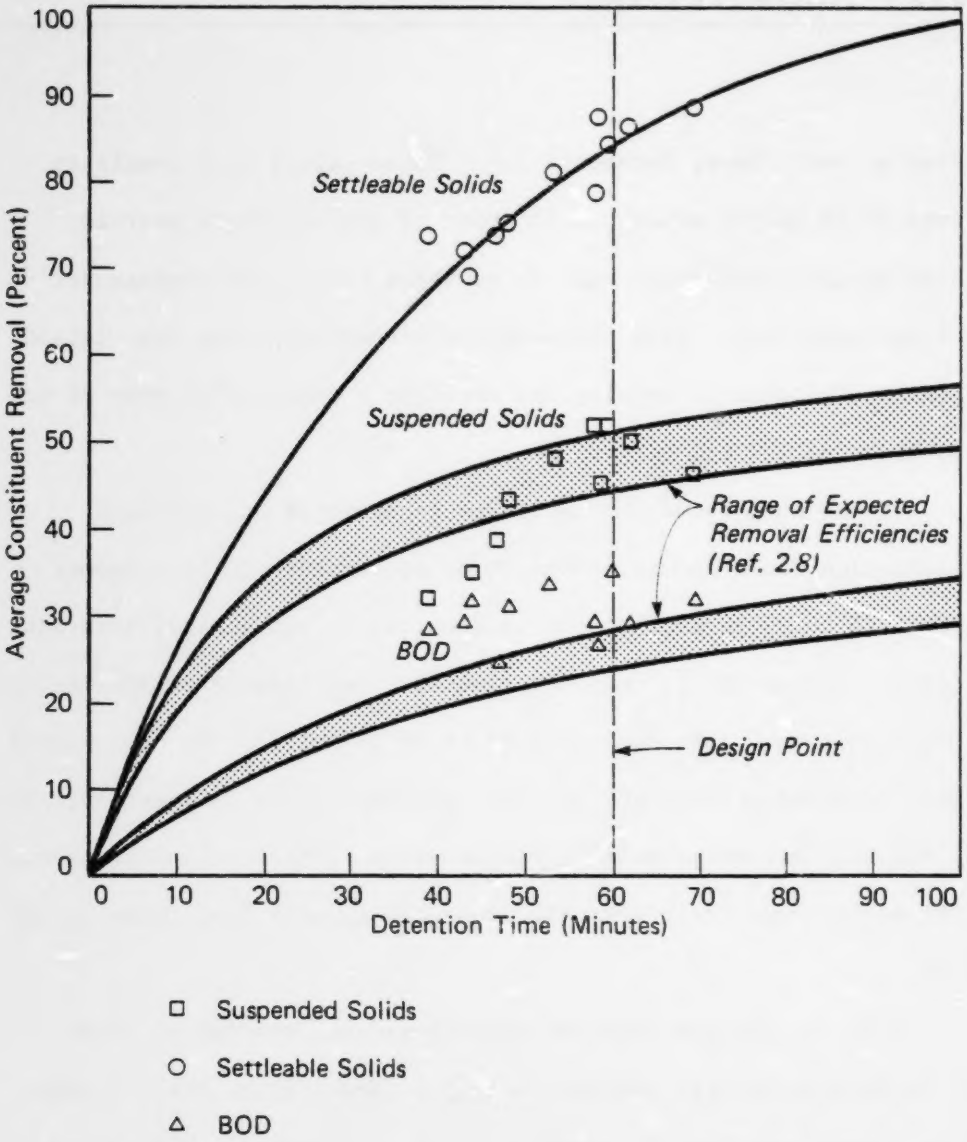
Even higher loading would have been experienced except for bypassing ahead of tunnel headworks and around the plant. We have been advised that one reason for so many sedimentation tanks being inoperable at various times is due to ice damage to clarifier equipment at Deer Island. Snow removal in Boston is primarily into the combined sewers, which lowers sewage temperatures to near freezing. When exposed to further cooling in the sedimentation tanks, ice formation on clarifier equipment causes jamming and equipment damage. Corrosion of the sedimentation tank equipment, conduits, pumps and exposed apparatus which results in equipment failure is a result of high sea water inflows into the sewers as well as sea spray.

As is revealed by Figure 2-3, the overloading of the individual sedimentation tanks resulted in average monthly detention times as low as 39 minutes, and surface loading rates as high as 2800 GPD/ft^2. It must be kept in mind that these values are monthly averages, with even more extreme values occurring from day to day. If all the sedimentation tanks were kept operating, the average flows now permitted to enter Deer Island today would result in overflow rates approximating the design value of 1750 GPD/ft^2. If all tributary flows were accommodated, the existing tanks would be significantly overloaded much of the time.

We have also plotted on Figure 2-3 the values of overflow rates commonly used in the design of efficient primary settling tanks. For the size tanks at Deer Island (245' x 100' x 10'), the design values of 600 to 1200 GPD/ft^2 are used in normal practice and a loading of 1200 GPD/ft^2 should not be exceeded at peak flows, Reference 2.7. These values will result in detention times of 90 to 180 minutes. In order to achieve these overflow rates, the flow in each tank would have to be between 14.7 mgd average daily flow and 29.4 mgd peak flow. With these design assumptions, the Deer Island Plant would, with six tanks in service, be rated at a capacity of only 88 mgd average daily flow and 176 mgd peak flow.

It has been found that efficiently designed and operated primary sedimentation tanks should remove 50 to 65 percent of the suspended solids, and from 25 to 40 percent of the biochemical oxygen demand, Reference 2.7. In addition, substantially complete removal of settleable solids can be achieved. Table 2-1 shows that during fiscal year 1975-1976, the Deer Island Treatment Plant reported removal of 79%, 30%, and 43% of the influent settleable solids, BOD, and suspended solids, respectively. These values are annual averages, with monthly and daily removals diverging greatly from these annual means.

When the average reported monthly percent removal of these constituents is plotted against average detention time (Figure 2-4), a trend towards higher removals at longer detention times is observed. The ranges of removals of BOD and suspended solids to be expected at various detention times, Reference 2.8, are also shown. For the detention times experienced at Deer Island, from the reported data it appears that the plant is achieving the expected removal of suspended solids, and better than expected removal of BOD. It should be noted, however, that the higher removals occurred when the flow rate was low enough to result in a detention time of 60 minutes (the design value). Under these conditions, the following removals were reported to occur:



NSF Boston Case Study, Phase II Evaluation

TREATMENT EFFICIENCIES AT DEER ISLAND STP
(Monthly Averages, 7/75 - 6/76)

Kennedy Engineers, Inc.
1977

Figure **2·4**

settleable solids: 78-87%
suspended solids: 45-52%
BOD: 27-35%.

These removals approximate very closely the removals to be expected for sedimentation tanks, even though the overflow rate is above the recommended 1750 gallons per day per square foot. It is emphasized that performance should be related to the number of sedimentation tanks operating. It is also to be noted that these reported removals relate to average daily flows, while peak flow rates will result in lesser removals. This is particularly true when sustained high flows occur during wet weather.

Table 2-3 presents the volumes and characteristics of the concentrated sludge entering the digesters, as well as those of the sludge discharged to sea. The volumes of the concentrated scum sent to the digesters are also presented. The data were obtained from the monthly data sheets of the M.D.C., reference 2.6.

The thickened sludge is sampled every two hours and composited daily, reference 2.4. The characteristics of these composite samples are subsequently determined and reported.

The supernatant from the sludge thickeners is returned to the head end of the plant, but the quantity and concentration of this flow are not reported. The quantity and concentration of the raw sludge that is removed from the sedimentation tanks to the thickeners are also not reported. However, we have deduced that this flow is on the order of one million gallons per day, at a solids content of approximately one per cent.

TABLE 2-3

DEER ISLAND - SLUDGE AND SCUM CHARACTERISTICS

(Reference 2.6)

	INFLUENT TO DIGESTER				EFFLUENT TO OUTFALL			
MONTH/YR	SLUDGE FLOW (1000 GAL/DAY)	TOTAL SOLIDS (%)	VOLATILE SOLIDS (% of T.S.)	SCUM FLOW (1000 GAL/DAY)	SLUDGE & SCUM (1000 GAL/DAY)	TOTAL SOLIDS (%)	VOLATILE SOLIDS (% of T.S.)	GAS PRODUCED (1000 CF PER DAY)
JULY, 1975	296	6.0	67	21	309	2.5	45.3	762
AUG, 1975	299*	7.4*	70.5*	22*	308	3.2	48.7	814
	* Based on partial month's data							
OCT, 1975	318	7.1	71.6	28	326	2.2	50.0	652
NOV, 1975	326	8.3	71.9	26	339	2.2	52.5	730
DEC, 1975	293	7.0	70.2	21	306	2.2	50.4	800
JAN, 1976	241	6.3	67.6	27	268	1.8	50.1	593
FEB, 1976	304	5.5	69.3	33	337	2.5	43.9	370
APR, 1976	320	6.3	70.8	30	350	2.1	52.5	798
MAY, 1976	314	6.1	70.6	23	337	2.2	47.1	751
JUNE, 1976	317	7.3	72.6	31	348	3.4	45.0	619
AVERAGE (10 Months)	303	6.7	70.2	26	323 *	2.4 *	48.6	689

* Pounds of dry solids per day = 323,000 gallons x 8.345 pounds per gallon x 2.4% = 64,700.

Although detailed analyses of the qualities of the undigested and digested sludge, and digester efficiencies are beyond the scope of the study, it is desirable to get a rough estimate of the pollutional load to the harbor that is caused by the digested sludge.

The only reported values of the BOD exerted by the digested sludge was found in a study done by Hydroscience, Inc. in 1971, reference 2.9. The two values of BOD from this report were 37,400 mg/l and 26,600 mg/l for the carbonaceous BOD of the Deer Island sludge in the years 1968 and 1969, respectively. Although our concern was to compute the BOD loading on the harbor from the sludge during fiscal year 1975-76, we do not feel that those BOD concentrations can be effectively applied in these computations. One reason for this is that the BOD values for the year 1968 may be the result of the new digesters just getting started and not yet reaching equilibrium. Therefore, it is unknown whether the lower value is representative of present conditions. Another reason to doubt the applicability of the values is that they are approximately ten times greater than those for Nut Island sludge. The Phase II sludge consultant should attempt to determine the BOD of Deer Island's sludge.

Unfortunately, we do not have enough data to confirm the monthly solids loading on the Harbor from the Deer Island sludge for fiscal year 1975-76. It is reported that the total solids loading during the year amounted to 36,400,000 dry pounds, reference 2.10. This is equivalent to 99,700 pounds of solids released per day to the harbor. The data is Table 2-3, however, indicate slightly less than 65,000 pounds per day, a conflict with the data in the Annual Report.

In order to estimate the efficiency of the Deer Island sludge digestion facility, it is necessary to consider the solids content of the sludge discharged to the Harbor, both with the sewage effluent and separately. The solids removal efficiency reduces from 45% (when the sludge content is ignored), to 18% when including the digested sludge discharge. The reason for this decrease in efficiency is that discharging the sludge to the Harbor returns 60 percent of the solids removed in the sedimentation tanks. The hourly impact of the sludge is even more dramatic when it is realized that the sludge load is only released for a maximum of eight hours per day (following the two high tides).

There is some concern that wastewater strength and removal data reported by MDC may not be representative of true performance of the facilities. We were advised that composite samples normally are not flow proportioned which would reduce the effect of lower removals at higher flows. In addition, sampling is only performed five days a week and not all days sampled are included in monthly averages. In order to get a true picture of plant performance, flow proportioned composites should be taken preferably with influent and effluent composite samples offset by basin detention time.

There also appears to be no record of amount and quality of direct bypasses around the treatment plant.

In summary, although tremendous daily fluctuations of sewage flow occurred, the average annual flow rate permitted to enter the Deer Island plant during fiscal year 1975-76 was less than the average daily design value of 343 mgd. The average overflow rate was higher than the design value and the average detention time was correspondingly lower due to the fact that two or more sedimentation tanks were out of service over half the time. Even under these conditions, though, reported removal efficiencies were close to those expected for efficient primary treatment, and the data indicate that the sedimentation tanks were performing well under the circumstances. Another critical factor in tank design is the configuration of inlets and outlets of the tanks. This design appears excellent at Deer Island and contributes to the absence of short circuiting.

b. Performance from July, 1971 through June, 1975. Every year, the Metropolitan District Commission, Sewerage Division publishes an annual report detailing the operations of the Division. Included in the report is a summary of the performance of the Deer Island Sewage Treatment Plant during the fiscal year covered by the report. For comparative purposes, some of the values from the reports are presented in Table 2-4, references 2.1, 2.10-2.13, along with the average values generated from the plant operation data sheets for fiscal year 75-76.

After the computations were performed to produce the data shown for FY 1975-76 from the monthly data sheets, the MDC Annual Report for that year was received. The corresponding values from this annual report are shown on Table 2-4 in parenthesis to allow for comparison.

The only value shown on the table for fiscal year 1976 that seems inconsistent with the other values is that which we reported for the total solids content of the sludge. While the monthly data sheets show an average solids content of 2.4%, the MDC Annual Report presents a value of 3.7%

TABLE 2-4

DEER ISLAND ANNUAL PERFORMANCE COMPARISON

		FISCAL YEAR ENDING				
		1972	1973	1974	1975	1976*
PLANT EFFLUENT	Average Daily Effluent Flow Rate (mgd)	329	343	299	292	327 (329)
	% Removal Suspended Solids (neglecting sludge)	43.2	47.3	56	59	43 (45)
	% Removal BOD_5	26.9	30.0	33	34	30 (30)
	% Removal Settleable Solids	73.5	66.5	78	82	79 (82)
	% Kill of Bacteria	>99.9	>99.9	>99.9	>99.9	(>99.9)
SLUDGE	Average Daily Digested Sludge Quantity (mgd)	0.29	0.28	0.31	0.28	0.30 (0.32)
	(1000 dry pounds)	96	86	100	94	(99.7)
	Total Solids Content (%)	4.0	3.6	3.9	4.0	2.4 (3.7)
	Volatile Solids Content (%)	49.4	47.7	48.3	49.5	48.6 (47.8)
	Overall % Removal Suspended Solids	17.1	24.4	25.2	35.5	18.1

* Value in parenthesis is obtained from MDC Annual Report. Other values for 1976 obtained from MDC monthly data sheets.

which is consistent with the data reported in previous years. While it is true that we only used ten months of sludge data in order to obtain this value, it is unlikely that the missing two months would completely account for the discrepancy between our value and the Annual Report's value. We cannot explain the reason for this discrepancy.

c. Comparison with NPDES permit requirements. In this section, we will compare the performance of the Deer Island facility during fiscal year 1975-76 with the NPDES permit requirements mentioned earlier in the chapter. It should be noted that the current permit for the MDC was not in effect during fiscal year 75-76. However, we feel that a comparison between the available data and the present requirements should be made in order to identify areas of non-compliance which will require improvements.

Table 2-5 presents this comparison. When filling in the last two columns of the table, it became apparent that the EPA's definitions of weekly and monthly averages are unclear.* It is not known if any three days of data can be considered to be a week, or if they have to be consecutive days or if they can be selected by the discharger. For this comparison it is considered that a weekly or monthly average is the average of all the daily data obtained during a calendar week or month, respectively.

Table 2-5 shows that, for the flows treated, most of the effluent limitations of the present MDC permit would have been complied with had the same requirements been in effect during fiscal year 75-76. The major exception is the daily effluent limitation on settleable solids which was exceeded ten percent of the time. It can be expected that the other effluent limitations

---

* (Weekly and monthly averages are the averages of 3 and 12 days of data, as defined in the permit.)

TABLE 2-5

DEER ISLAND PERMIT COMPLIANCE
(FY 1975-76)

VARIABLE	UNITS	EFFLUENT LIMITATION AVERAGES				NUMBER AVERAGING PERIODS	APPARENT VIOLATIONS
		DAILY	WEEKLY	MONTHLY	YEARLY		
Flow	mgd	-	-	-	403	1	0*
Bio. Oxygen Demand 5-day, 20°C	mg/l	200	-	-	-	220	0
	mg/l	-	145	-	-	46	0
	mg/l	-	-	140	-	11	0
	lbs/day	-	-	474,000	-	11	0
	percent removal	-	-	-	26	1	0
Total Susp. Solids	mg/l	140	-	-	-	236	0
	mg/l	-	94	-	-	49	1
	mg/l	-	-	91	-	11	0
	lbs/day	-	-	306,000	-	11	0
	percent removal	-	-	-	42	1	0
Settleable Solids	ml/l	1.5	-	-	-	236	29
Fecal Coliform Bacteria	- Provide continuous chlorination....................................						0
Total Coliform Bacteria	- Provide continuous chlorination....................................						0

* Flow was artifically limited by throttling at headworks.

were not exceeded, as the limitations are generally quite lenient. Plans to improve treatment at Deer Island will be covered in a later section of this chapter.

It is important to note that the average flow to the plant is artifically controlled by pumping limitations, direct bypass around the plant, overflows to the shoreline when headworks influent gates are the throttled and by direct discharge to the Inner Harbor from the Chelsea Creek pump station. If all tributary flows were accepted at the treatment plant, the NPDES capacity would be greatly exceeded during wet-weather and removals would decrease with probable violation of effluent limits.

4. KENNEDY ENGINEERS' OBSERVATIONS OF FACILITIES

The MDC facilities were visited by members of our organization during May, September and October 1976. During these visits, the Deer Island Treatment Plant was visited and interviews held with key personnel. Construction drawings were reviewed in the MDC headquarters office. The following discussion summarizes our observations and the deficiencies we noted.

In spite of the efficient primary treatment and the fact that there is no detectable degradation of the receiving waters from the effluent (without sludge solids), the Deer Island treatment facilities are a major cause of water quality problems in Boston Harbor. This is due to the quantity and frequency of intentional by-passing and overflows and combined sewer discharges into rivers, estuaries and shoreline locations due to inadequate hydraulic capacity. Whenever the capacity of the Deer Island pump station or the treatment facilities in operation is reached, the influent gates at the three tunnel headworks are throttled and overflows occur. These overflows are apparently not limited to storm occurences. Since the headworks gates are not designed for throttling, the spray at the operating level of the screen rooms becomes unsafe and a hazard to health. Action should be taken to eliminate the necessity for influent throttling.

A major step in controlling overflows and by-passing would be to provide adequate, reliable pumping capacity at Deer Island. Merely replacing the unreliable drive units at the pump station will not accomplish this.

The present pumping units are reported to be operated at less than design maximum draw-down and at less than design maximum operating speed. Severe erosion of pump impellers has been experienced and frequent replacement of impellers has been required to control vibration and loss of capacity. Vibrations of shafts and bearings have also been a problem.

A brief review of pump arrangement disclosed that the alternative inflows to the pumps from the Chelsea Tunnel and the Main Tunnel is accomplished by a breeches Wye connected to the pump inlet with valves on each inlet leg of the Wye. One of the valves is always closed. This is a very unsatisfactory hydraulic arrangement and almost certain to cause turbulence at the eye of the impeller and probably induce impeller cavitation, unbalance and erosion. Possible correction could be to remove the breeches Wye and make a smooth connection to one tunnel or the other. Another possible alternative would be to open both valves and pump from both tunnels at the same time. This would, however, require an upstream interconnection between the two tunnels to balance suction head. The third and preferable alternative would be to build a new pump station to serve one of the tunnels and use the existing pump station (with Wye removal) for the other tunnel.

A brief analysis indicates the Boston Main Tunnel should have a capacity in excess of 1000 mgd and the North Metro Relief Tunnel (Chelsea) a capacity in excess of 500 mgd. If adequate pumping and treatment capacity is provided at Deer Island (and possible increase in headworks capacity), a majority of bypasses and overflows could be eliminated. The exact percentage cannot be estimated due to lack of data on frequency and quantity of present overflows and bypasses.

The limited capacity in the Deer Island treatment plant caused by frequent sedimentation tank equipment failure is reported as a reason for some of the headworks throttling. The frequency, duration and quantity of bypassing around the plant is not reported. However, the present primary plant design peak capacity of 848 mgd is less than the present 1080 mgd design influent pumping capacity. If the influent pumping capacity is increased to 1500 mgd or more in order to control overflows and bypasses, the primary treatment capacity is clearly inadequate. This method of overflow and bypass control should be studied in detail.

The existing Deer Island treatment plant uses sedimentation tanks for gravity solids separation. The efficiency of wastewater primary treatment facilities is related to the sedimentation tank surface loading rates, detention time and hydraulic characteristics of the tanks.

Critical factors which affect hydraulic efficiency are tank inlet and outlet conditions. A review of the construction drawings indicates that the design of the Deer Island tanks provided adequate or perhaps excellent inlet and outlet conditions, which would be expected to distribute flows quite uniformly over the cross-section of the tanks. Field inspection indicated that the inlet and outlet arrangements result in good uniform distribution across the tanks with little short circuiting and that the tanks appear to be performing as intended by design.

It was learned that several sedimentation tanks are often out of service for maintenance or repairs of the sludge collection mechanisms as noted earlier. This frequently occurring condition increases the loading and decreases performance of the other tanks.

The Deer Island plant includes various, complex supplemental systems, some of which are in disrepair but not to the extent of the similar systems at the older Nut Island plant. The Deer Island plant includes an influent pump station which receives flow from three remote headworks structures. This pump station employs now obsolete radial engine driven pumps. Often several of the engines are out of service for repairs, which forces flows to back up at the headworks. Two of the pumps appear to be permanently inoperative. Also, the manifold piping to each pump's suction is designed such that it may draw wastewater from either the tunnel serving Ward St. and Columbus Park headworks or the tunnel from Chelsea Creek headworks but not both at the same time. The manifolding also limits the flexibility of the pump station to accommodate all the flow from both tunnels as needed, necessitating throttling headworks inflow and diverting to overflows. A portion of the diverted flow from the Ward Street headworks can also enter the recently constructed Cottage

Farm detention and chlorination facilities. A portion of the diverted flow at Columbus Park headworks can be pumped by the City of Boston via Calf Pasture to Moon Island. Backup at Chelsea headworks can be pumped to Winthrop Terminal but usually is allowed to overflow into Chelsea Creek.

a. Basic objectives to be accomplished. To obtain maximum effectiveness of the Deer Island plant, the following basic objectives should be accomplished.

(1) Modify the primary sedimentation tank mechanisms and/or enclose the basins to avoid the failures presently causing frequent removal of sedimentation tanks from service.

(2) The sedimentation tank design criteria is high in surface loading rates and low in detention time in comparison to conventional design criteria. A program to increase capacity and to improve treatment efficiency should be undertaken especially since present design inflow capacity exceeds plant capacity. If additional pumping capacity is provided, further enlargement of plant capacity will be required. The EMMA program proposes some additional primary sedimentation tanks in order to reduce loading rates but not to significantly increase treatment capacity.

(3) The frequency and amount of combined sewer overflows can be reduced by providing more dependable pumping capacity at Deer Island.

Presently planned programs for replacement of the influent pump drive units should be expedited. Facilities should be managed to avoid backup from Ward Street headworks and resulting overflows to the Charles River. Making use of East Boston pump stations and Winthrop Terminal to full capacity during high flow conditions would reduce overflows in East Boston. Pumping capacity from the Boston Main Drainage Tunnel should be reliably increased to entirely avoid backup from Columbus Park onto Dorchester Bay beaches.

We have computed that the reported rated capacities of the three tunnels are based upon friction losses and velocities as follows:

Tunnel	Size	Flow MGD	Velocity Feet/minute	Head Loss Feet/1000'
Ward to Columbus Park	120"	260	5 1/4	0.60
Columbus Park to Deer Is. (Boston Main Drainage Tunnel)	138"	440	6 3/4	0.87
Chelsea Creek to Deer Is. (North Metro Relief Tunnel)	120"	350	6 3/4	0.98

If steps were taken to enable operation of the Main Deer Island Pumps so they would draw the water level down to a lower level, particularly during wet weather, more wastewater could be conveyed to Deer Island from the sewers of member communities and less would overflow. The increase in velocity and flow would have two other impacts. First, there would be more pumping head and energy expended, and there would be lowered performance in the sedimentation tanks. Even if the sedimentation tanks were bypassed however, the wastewater could be chlorinated and discharged to deep waters of Boston Harbor rather than to the Charles River Basin and shoreline areas.

(4) Present sludge handling, digestion and disposal practices result in a significant pollution loading to the Harbor. Changes in the sludge disposal method, such as implementation of sludge incineration or land disposal may make the single most significant impact on the water conditions in the

Bay. We have calculated that the present solids loading discharged to the Harbor by Deer Island could be reduced by about 21 percent, if sludge is incinerated or disposed of on land.

(5) The three relief off-shore effluent outfalls should be extended with diffusers in deeper waters rather than close to the island shoreline. Also, a monitoring program of outfall headloss and diffuser operation should be implemented. To our knowledge, nothing has been done to correct the main diffuser clogging problems noted in 1973 by TCE, Inc. in their report entitled "Structural Evaluations and Ecological Observations in Boston Harbor," reference 2.14.

(6) Present chlorine diffusion in the effluent channel by a series of vertical pipes is inefficient. Chlorine mixing and contact time is considered inadequate at present. Improved diffusion and mixing of chlorine solution with the effluent and addition of a chlorine contact chamber should improve coliform reductions. Criteria should conform with Guides for the Design of Wastewater Treatment Works, reference 2.15.

(7) Although the treatment plant facilities were, at the time of our visits only eight-years old, general conditions at the plant make it appear much older due to the extreme atmosphere in which they exist. The sewer gases at sewage treatment plants combined with salt air are noted for their corrosive effects upon equipment and metal structural features. At Deer Island, the conditions have created such a severe corrosion condition that significant repairs to plant appurtenances are already necessary. Therefore, a program should be developed and implemented to make the necessary repairs of deteriorated

mechanical, electrical and architectural items. It is estimated that this program alone could cost approximately twenty percent of the cost of constructing a new, similar plant. Following correction of present defects, a sound maintenance program should be funded to protect the plant from further deterioration as is presently being experienced.

Items 1 and 2 above focused upon the deficiences of the sedimentation tanks, which are the heart of the primary treatment plant. The following possible methods of improving treatment performance could be advantageously employed. They could be employed as merely interim improvements or as permanent improvements.

b. Reducing sedimentation tank difficulties. As was explained earlier, one reason for the excessively high overflow rates and low detention times in the settling tanks is that not all tanks are available for use all of the time. Since the wastewater flow entering the treatment facility is independent of the number of tanks in operation, having tanks out of service results in higher flow rates through the other tanks.

It is necessary for one sedimentation tank to be out of service due to periodic maintenance and repairs occasionally, but Table 2-2 shows that up to 4 tanks were not operable for full days during fiscal year 1975-76. The major cause of this is reported to be caused by ice formation on tank surfaces which either bends the steel collectors or overloads the equipment, causing rapid deterioration and loss of ability to remove sludge and scum.

One way to protect the sedimentation tanks and associated hardware from such environmental extremes is to erect a building over the existing tanks. Preliminary estimates show that the cost of constructing such a building covering the existing sedimentation tanks is estimated to be approximately $5 million, including lighting and ventilation equipment. An air inflated enclosure could be obtained for less than one fourth the cost of a building. We would recommend consideration of tank enclosure for improving treatment and believe it warrants further investigation.

(1) Chemical addition to improve sedimentation. While chemical addition has been used at some plants to improve the efficiency of primary clarification, it not now generally used where primary treatment systems are followed by secondary treatment, reference 2.16.

The chemicals commonly used to improve primary clarification are iron and aluminum salts, and organic polyelectrolytes. Lime (calcium hydroxide) is also effective in coagulating wastewater and improving settling, although the use of lime results in an effluent that has a high pH (9.0-11.5). The addition of these chemicals improves clarification by agglomeration of colloidal particles which settle readily in a clarifier.

Polyelectrolyte addition has been found to improve suspended solids and BOD removals from 38 percent and 31 percent to 65 percent and 47 percent, respectively. It has also been found, and reported by EPA, that the effect of polyelectrolyte addition is pronounced when existing suspended solids removals is poor.

Analyses of raw influent at Deer Island indicate high salinity variation at the plant probably due to salt water inflow through faulty tide gates. Salinity concentrations and temperature variations in the influent wastewater could hinder the effectiveness of this chemical coagulation. Further detailed consideration should be given this issue before it can be recommended. Salinity is also discussed in Chapter 6.

(2) Use of tube settlers, reference 2.16. Tube settlers are sometimes installed in a sedimentation tank in module groupings. They enhance the ability to capture settleable solids because once a particle strikes the wall of a tube, it is effectively removed from the waste flow. In effect, the depth of settling is reduced to a few inches once the particle is in the tube.

Studies have shown that the settlers can produce adequate removals at overflow rates of up to 5000 GPD/square foot. However, they will not remove colloidal particles that tend to remain in suspension, as coagulation is not enhanced by the tube setters.

While tube settlers may help to increase removals at Deer Island, there would be a problem of installing them in the sedimentation tanks. Since the existing travelling bridges have both a scum collector at the top of the tank and a sludge collector at the bottom, the collector mechanisms would require major revision.

It seems likely that the expense and difficulty of installation may make the use of tube settlers unfeasible, when compared with the increment of additional removal efficiency that would be obtained.

c. Other deficiencies and recommendations. In addition to the major concerns presented earlier in this section, the following list of observed deficiencies and recommended programs has been developed as a result of our field examinations.

(1) Improved sampling facilities are needed. Each sample station should have a pump to discharge to a sampling sink and to a multiple container sampler with provisions for compositing and preserving fresh samples and apparatus for performing tests on constituents which decay with time, all housed in a weatherproof building with readout of flow meter. The existing composite sampler which takes constant amounts of sample at equal time intervals does not produce representative results and should not be used.

(2) Need to be able to record duration and quantity of plant bypass and overflow.

(3) Need means to measure the quantity and to determine the quality of various sub-streams in the plant which are not reported, such as:

(a) Raw sludge pumped from the sedimentation tanks to the thickeners,

(b) Supernatant overflow returned from the sludge thickeners back to the plant influent,

(c) Raw scum pumped from the scum collection pit to the scum concentration tanks,

(d) Concentrated scum pumped from the scum concentration tanks to the sludge digesters,

(e) Scum underflow returned from the scum concentration tanks back to the plant influent, and

(f) Reclaimed water pumped from the plant effluent to the plant process water system.

(4) Primary sensing devices such as level transmitters all need standby units plus a readily available permanently installed means of calibrating and checking their accuracy such as a staff gauge marked in the same units of measurement as the transmitter and receiver.

(5) Need to perform most sampling and laboratory analyses daily. At present, data are available for approximately 18 to 20 days per month.

(6) Need to periodically analyze grab samples taken at times of peak flow and/or peak tides.

(7) Need reliable filtration and other improvements to the reclaimed process water system to increase reliability of ancillary support systems. (An alternative would be to develop a new source of supply such as connection to public water service adequately protected from back-flow by air-gap.)

(8) Need means to measure quantity and quality of gas produced by each digester, to aid in performing a mass-balance on sludge management facilities.

(9) Need reliable residual chlorine analyzer-recorder-controller system, with standby, in atmospherically controlled environment.

(10) Need sampling and BOD analyses of sludge discharged to Boston Harbor to evaluate total effluent loadings, rather than just the primary sewage effluent.

(11) Need a contingency plan to assure continued operation during strikes or natural disasters.

(12) Need standby units on certain key equipment and controls to increase reliability of systems often interrupted for extended periods by minor equipment failure.

(13) Need to thoroughly review all facilities for reasonable safety aspects and implement certain badly needed repairs, replacements or additions to reduce rate of occupational accidents and illnesses and to reduce hazards. Although the U.S Department of Labor's Occupational Safety and Health Standards are not yet applicable to publicly owned facilities in the Commonwealth of Massachusetts, they would serve as useful guidance in analyzing the risks at existing facilities. We would expect an indirect benefit due to improved morale and more reliability of operation due to fewer lost workdays.

(14) Need formal operation and maintenance manuals and training programs as discussed later in this chapter.

(15) Certain portions of the existing buildings and grounds must be modified to be accessible by and usable by the physically handicapped if a Clean Water Grant is accepted for other additions or improvements to the facilities.

(16) Suggest color-code painting all process and chemical piping for safety and identification purposes. Recommend conformance to a standard system such as the one recommended in reference 2.15. Coding and identification is a requirement of Clean Water Grant Program projects.

(17) Wastewater sampling and analysis should be undertaken to correlate rate of flow with plant influent and effluent quality. Present non-flow proportioned sampling and reduction of data to average values without consideration of flow and loading rates is non-representative of plant performance.

5. TUNNEL HEADWORKS

There are no data on peak tributary flows to the three headworks facilities or on the flow quantities diverted to overflows when headworks influent gates are throttled due to exceeding available pumping capacity or headworks capacity. The rated capacity of the tunnels appears to be based on the rated peak flow capacity of tributary headworks and not on the actual hydraulic capacity of the tunnels, which appears to be in excess of the "rated capacity."

Records indicate that, on occasion, the flows through the headworks have exceeded "peak rated capacity." It is not known what actual peak capacity of each of the three headworks structures is as, due to pumping limitations, backing up in the headworks is the present limitation. When backing up occurs, bar screens are overtopped and large solids float over the screens and plug the grit conveyor system and may cause problems in the treatment facilities. We were advised that there are no data on the effectiveness of the grit basins. The amount of grit in treatment plant digesters gives concern as does the amount of grit which may have accumulated in the tunnels.

If the Deer Island pumping capacity is increased, it appears that headworks screening and grit removal capacity must be increased unless actual peak flow capacity of the facilities is significantly greater than the "peak rated flow."

Inflow into each headworks is controlled as directed from Control Center at Deer Island Pump Station by throttling the influent slide gates. These gates are not designed for throttling service and release raw sewage above the slide onto the screen operating floor, causing a work hazard and also release spray into the work area as mentioned earlier. It does not appear that the amount of throttling at each headworks is based on rated maximum utilization of the Cottage Farm detention basin, but rather on an arbitrary distribution of flows. The need for throttling inflow should be eliminated.

Also, the gates are slow in closing and on at least on occasion when pumping capacity at Deer Island was suddenly lost, at one of the headworks the screen room work floor was rapidly flooded several feet deep before influent gates could close presenting a severe hazard to operating personnel.

6. JOINT TASK FORCE OBSERVATIONS OF DEER ISLAND

During the period of March 29 through April 30, 1976 personnel from the Division of Water Pollution Control of the Commonwealth of Massachusetts joined with personnel from the Operation and Maintenance Section of the EPA Region I to investigate the major MDC facilities located in the Boston area. The need stemmed from a major breakdown of the Nut Island facility which resulted in prolonged bypassing of the treatment plant. Consequently, the study concentrated on reviewing operations at the Nut Island Treatment Plant with the aim of making recommendations for improvements. However, conditions at Deer Island and it's headworks, the pumping stations serving Nut Island and the Cottage Farm Stormwater Detention and Chlorination Facility were also studied to allow a comparison between facilities.

In May, 1976 a draft copy of the report was produced by the Joint Task Force. This section reviews the findings, conclusions, and recommendations of that report, reference 2.4.

a. Deer Island Headworks.

(1) Present status: The major problems at the Chelsea Creek headworks are reported to be spray from influent gates when throttled and inefficient screening. At the Columbus Headworks, the low slope and large capacity of the tributary sewer systems sometimes results in the influent sewage turning septic during low flow conditions. This creates odor problems at the headworks. The tide gates on the system leak which result in sea water inflow as well as the discharge of raw sewage near beaches during surcharge conditions. Odor problems are mentioned at the Ward Street Headworks.

The Task Force reports the replacing and repairing of the system's tidegates by the MDC, although severe sea water inflow still seems to occur. Approximately twenty men staff each of the headworks, consisting of a supervisor, a maintenance staff and a 24-hour operation staff.

(2) Task Force recommendations:

(a) "Maintenance should be continued at all headworks."
(b) "The leaking tidegates should be identified and repaired."
(c) "Insofar as possible, operations should minimize detention time of sewage in the sewerage system."
(d) "The efficiency of the Chelsea Creek screens should be improved."

b. The Winthrop Terminal facility.

(1) Present status: Although the Task Force states that the Terminal "appears to be exceptionally well maintained and operated by responsible, well trained personnel," numerous problems are identified at the facility. These include:

(a) inoperative wet well indicators

(b) problems with the air compressors, including inoperative pressure switches, air dryers, air motors and the moving filter mechanism

(c) prolonged repairing of one of the main pumps, making it inoperative for at least five months

(d) corroding grit collectors

(e) poor operation of the fine screen ejector system

(f) corroded doors to the grit room

(g) cleaning and painting of the grit and screen room is "badly needed."

c. Raw sewage pumping at Deer Island and power generation.

(1) Present status: Problems with the nine Nordberg engines have plagued the pumping facility since construction. At the time of the Task Force study, only three engines were operating on an unrestricted basis, providing less than 300 mgd capacity. Two engines were operating with speed restrictions, and the other four were not operating at all. Three of these non-operating engines were being repaired, while the fourth is permanently off line and is to be replaced by a 2000 HP electric motor. Occasionally, the facility has been down to two working engines, and it is problems with the engines that result in the discharges at tide gates, flooding headworks, and diversion of flow to Moon Island or to the Cottage Farm facility or back-up and flooding in the system.

No problems were reported with the Allis-Chalmers Pumps, and the power generation system appeared to be operating well. No mention was made of pump impeller erosion and pump unbalance.

Raw sewage pumping and power generation is staffed by a plant maintenance group and four five-man operation crews, which is a reduction of two men per shift from staffing prior to 1972. The Control Room is attended twenty-four hours a day, resulting in little vacation time for the Senior Power and Pumping Engineer.

Emergency overtime is sometimes authorized for the maintenance crew when there are problems with the Nordberg engines. However, the machine shop staff has been reduced from three to one machinist for at least five months, so repairs are slow.

The operators attempt to power the dual fuel equipment with the maximum percentage of digester gas, although the Task Force reports that there have been some problems due to insufficient gas in maintaining the Enterprise engine generators at 60 cycles. About 30 psig of gas pressure is needed to run the engines properly on gas. While the engines will operate entirely on fuel oil, they can be operated with as little as ten percent fuel oil. In an attempt to limit fuel oil purchases, the gas demand is such that pressure drops below the 30 psig needed.

d. Power distribution system.

(1) Present status: The five outdoor substations are reported to be in good condition. Problems reported by the Task Force are corroded lightning protection equipment and control boxes for the scum thickener electrical system.

There are seven men staffing the electrical department, and they are also responsible for electrical work at all of the headworks installations.

e. Control systems.

(1) Present status: The accuracy of the sensing devices for measuring flow and height of the sewage in the shafts at the headworks and at Deer Island is suspect as the devices are not calibrated on a regular basis and are coated with grease and other floatables. This instrumentation is used to determine the flow that can be accepted for discharge to the Deer Island pumps and consequently determine the degree of throttling necessary at the headworks. The Task Force reports that the MDC may replace the bubble tube sensors with ultrasonic level finders.

The microwave communication between Deer Island and the headworks has battery backup for emergency power, and a telephone line backup in the event of microwave interference. The Task Force believes that such redundancy will adequately maintain communications in the event of component failures.

Other instrumentation in the plant has been reduced to a minimum and only essential sensors and gauges have been repaired. Other problems noted in the report follow:

(a) In the Control Room, automatic effluent line bypass valves and their signals to the Control Room do not work. The total plant flow meter is out of service, and meters needed to provide equal distribution to the two sides of the treatment plant do not work.

(b) In the primary treatment area, pressure sensors for the Venturi meters on the sludge pumps and the scum flow meters are plugged with sludge.

(c) In the digester area, the automatic pilot system for igniting waste gas does not work. The temperature sensors in the digester are not accurate.

(d) The scale for the chlorine tankers has not been calibrated since 1968, and its accuracy is in question. The closed loop chlorination control system and the programmable daily rate controller have not worked almost since installation.

(2) Recommendations of the Task Force.

(a) "A further investigation of the control systems..."
(b) "The waste gas pilot lights and effluent relief valves should be returned to their former automatic state."
(c) "Sensing and metering equipment should be serviced on a regular basis."
(d) "Bubble tubes should be replaced with a device not subject to mechanical damage."

f. Primary sedimentation tanks. The Task Force reports that all of the tanks are in good condition, although new rails and sprockets are needed on a few of the tanks. They have all been drained and overhauled within the last three years.

While the sludge collector units are in good condition, the load on the scum cross collectors is too great. Consequently the operators must use paddles to help remove scum from the tanks.

The two main Wemco scum pumps have been recently overhauled, and the maintenance crew has recently or is presently overhauling the sludge pumps. The only problems reported with the sludge pumps appear to be leaking from the pump valves. However, none of the pressure guages worked. The pump house doors are corroded.

g. Chlorination. At the time of the Task Force investigation, six of the seven chlorine evaporators and seven of the eight chlorinators were in service. Although there are chlorine emergency kits in each room and chlorine gas detectors, the chlorine alarm panel has been out of service for three to four years.

The Task Force noted that repairs in the area of the chlorine injector apparatus require the complete shut-down of the disinfection facility.

One maintenance man is assigned to chlorination, and there are operators for testing for chlorine residual and for adjusting the feed rate.

The report recommends improvement of system reliability, repairing of the currently broken prechlorination line, and modifying of the chlorine diffuser at the Winthrop headworks. The diffuser is presently at too high an elevation to be of practical use in prechlorinating the Winthrop flow. There was no comment on the poor facilities for injection and diffusing chlorine solution for post-chlorination.

h. Sludge and scum thickening. No problems were reported with these processes at the Deer Island Treatment Plant. The tanks are all said to be in good condition, as are the scum and sludge pumps which have all been either overhauled or modified recently. Maintenance has been, and must continue to be good in this area.

i. Anaerobic digesters. The Task Force reported that all the digesters are routinely drained and cleaned, and that all three primary digesters have been overhauled in the last three years. There was no mention that digesters are now reported to be about one third full of grit.

Although each of the four draft tubes per digester is overhauled during each tank drawdown, one shaft tube was not functioning, and one was bent at the time of the Task Force inspection.

The pilot lights on the waste gas burner system do not work, and the burners must be periodically relit manually. The sludge heat exchangers were reported in good condition, and the recirculation pumps are all to be replaced with new units. All other sludge pumps were reported to work well, and the Task Force reports that new gas compressors are to be installed to reduce maintenance problems with the gas boosters.

The report emphasizes the need to routinely clean the digesters to keep scum buildup to a minimum. The tanks should also be periodically checked for grit.

j. Process water facility.

One of the three pumps at the effluent pump building was inoperative and a new motor had been ordered. Another of the motors overheats. Additional pumping capacity is being installed.

The report notes a break in the chlorine line from the chlorine building to the process water pump building, preventing its use to control algae at the reservoir. At the time of the study, repairs were underway at the reservoir stillwell sensor.

k. Maintenance record system. The Task Force found the Deer Island maintenance record system to be adequate. The maintenance personnel normally work a 40-hour week, and the operations personnel man the operations 24 hours a day.

Operation Logs are maintained and reviewed daily by the treatment plant mechanic. If necessary, he refers problems to the Senior Mechanical Engineer.

Detailed Work Orders are filled out and listed with staff assignments on a daily Assignment Sheet. All completed Work Orders are maintained for permanent reference. There is a Friday Preventive Maintenance Routine that is treated as a regular work order.

An assistant mechanical engineer is responsible for the inside maintenance crew, payroll, and supervision, while another assistant mechanical engineer performs similar work for the outside maintenance crew (including the headworks crew). Daily reports are submitted.

The Task Force reports that the minimum and maximum supply levels of parts in the stockroom have not been maintained for several years. They attribute this to a shortage of funds. Although a complete inventory of the stockroom is rare, spot checks are done frequently to make sure that recorded parts inventories are up-to-date.

l. Staffing and training at Deer Island. The following chart summarizes the staffing situation at the Deer Island complex compared with recommended EPA guidelines. The chart was developed by the Joint Task Force. Included is staffing at the headworks as well as at the treatment plant.

STAFFING	MNGMT	OPER	LAB	MAINT	OTHER	OFF/CLER	TOTAL
BUDGETED	6	87	6	120	7	5	231
RECOMMENDED**	4	69	5	59	7	3	147
ACTUAL	3	85	5	101	6	2	202
ACT-RECOM.	(1)	16		42	(1)	(1)	55
AVG. WAGE*	$19,719	$10,768	$13,051	$9298	$10,584	$8,146	$10,298

*Does not include overtime.

**Numbers were developed from a preliminary analysis based on extrapolated U.S. E.P.A. staffing guidelines. The numbers represent minimum needs for a well maintained and operated facility staffed with quality personnel. Variations between actual and recommended minimum numbers should be considered as potential problem areas that need examination by professional staffing experts.

The Task Force reports that 43% of the operations and maintenance personnel are certified, and 60% have received occupational training. Following is the breakdown of operator certification by grades:

GRADE VII	1	employee
GRADE VI	1	"
GRADE V	6	"
GRADE IV	7	"
GRADE III	3	"
GRADE II	4	"
GRADE I	16	"
	38	employees

An explanation and description of the certification grades are defined by EPA.

The Task Force also developed the following breakdown of educational levels at Deer Island.

EDUCATIONAL LEVEL	PERCENT
High School	60
Associate Degree	5
Bachelor Degree	2
Graduate Degree	2
Trade School	31

m. The Deer Island laboratory. The Task Force report details the sampling techniques and testing procedures employed by the laboratory. The plant is required by the NPDES permit to test the discharge using procedures described in the Federal Register Volume 38, No. 199 dated October 16, 1973. The study notes that the tests being performed for nitrate and nitrite nitrogen, total and orthophosphate phosphorous, chlorine, volatile suspended solids, total Kjeldahl nitrogen, total alkalinity and all metals tested by atomic absorption need to be reviewed and modified, as necessary, to conform to EPA requirements.

The study notes that no quality control is being practiced at the Deer Island laboratory. There is no program of checking the precision and accuracy of the analyst and measurement systems. Accordingly, the report details steps to improve the accuracy and reliability of the equipment and test results by the use of quality control.

The general comments and recommendations of the Task Force with regard to the laboratory follow:

(1) "Technical training of laboratory staff should be updated. Frequent staff turnover at the laboratory requires extensive on-the-job training which should be supplemented with professional seminars and journeyman-type courses which are available from EPA or similar State agencies. Special training should be given to the analytical requirements of PL 92-500 for NPDES purposes."

(2) "The vacant bacteriologist position should be filled. There is every reason to believe that the laboratory director should be released from bench testing so that he can more properly supervise and develop important programs, such as, quality control and upgrade his analytical methodology."

(3) "Equipment limitations should be removed and appropriate analytical procedures instituted to replace these non-quantitative Hach and OT-chlorine methods. Such data collected for NPDES purposes are not acceptable. Modifications of approved methods should be developed as given in the Federal Register for alternate procedures."

(4) "An intralaboratory quality control program should be initiated as soon as possible. This should include the development of statements of precision and accuracy (in the major effluent parameters) for the analyst and measurement system. A check sample performance evaluation survey should be conducted at least quarterly under the supervision of State authorities with EPA assistance if needed."

(5) "Operational problems of salt water intrusion (average 10% sea water based on chloride estimate) affect methane production, TKN buffer, BOD and COD."

The Task Force reported that non-representative scum samples were being obtained for laboratory testing as a result of the poor mixing in the digesters. It reported that a scum buildup in the digesters has resulted in each one having failed over the last seven years, although the laboratory samples have not reflected such a scum accumulation.

Also recognized are the limitations imposed by the fact that the digester gas can only be sampled at the sphere, after the gases from all the digesters have been blended together. Thus, the quality of gas in each digester cannot be determined, preventing closer control of each digester.

Finally, the report commends the special study programs conducted at the laboratory, such as sea water inflow determinations, sediment analyses, and corrosion control studies. There was no comment on the fact that laboratory analyses are only available for less than two-thirds of the days in a month and that daily testing should be provided.

7. EMMA PLAN TO IMPROVE PRIMARY TREATMENT AT DEER ISLAND

In March 1976, the Wastewater Engineering and Management Plan for the Boston Harbor - Eastern Massachusetts Metropolitan Area (EMMA Study) was completed. The Study, which was performed for the MDC, makes extensive recommendations regarding the wastewater facilities situation in the Eastern Massachusetts area, including costs and a timetable for implementing the Recommended Plan. This Study has been approved, with modifications by the EPA, and the revised schedule has been incorporated into the Enforcement Compliance Schedule Letter for the MDC.

Most of the EMMA Study recommendations will be discussed in Chapter 3, but we include herein a review of the EPA approved plan for improving primary treatment at Deer Island.

a. The EMMA Recommended Plan with regard to primary treatment at Deer Island, references 2.3, 2.17. Primary plant improvements at Deer Island are scheduled as Priority Item No. 6 with a target completion date set for summer of 1984.

The Recommended Plan proposes increasing the Deer Island service area from the present 68,200 to 87,600 sewered acres by the year 2000. Some of the design criteria used in the EMMA Study for the expansion of the Deer Island plant are presented in Table 2-6.

The value of 336 mgd for the present flow used in Table 2-6 is comparable to the average daily flows that have historically been accepted at the Deer Island plant. The peak daily flow of 573 mgd is based upon flows accepted by the plant, reference 2.6, but appears significantly below the peak flows tributary to the facilities, most of which are by-passed or overflowed. The peak flow of 845 mgd is based on the flow which historically was accepted by the plant during fiscal year 1972-1973.

The sedimentation tank surface loading rates that these flows correspond to (1749, 2983, 4399 GPD/SF, respectively) are those values that will occur only if all eight sedimentation tanks are operating. As was shown earlier, with only an average of 6 1/2 tanks in service during fiscal year 1975-76, these surface loading rates would increase to 2153, 3671, and 5414 GPD/SF, respectively. When more tanks are out of service, rates will greatly increase. Thus before the overflow rates in Table 2-6 can be met, it is necessary to keep the eight settling tanks operating.

The EMMA Recommended Plan would increase the average daily flow to 400 mgd in the year 2000, and to 430 mgd in the year 2050. The peak day flows are increased to 731 mgd and 782 mgd for the same design years. The increases in flow were based on industrial, commercial, and residential wastewater flows, and included an allowance for infiltration.

TABLE 2-6

BASIC DESIGN CRITERIA - DEER ISLAND EXPANSION
(Reference 2.17)

	Present	2000 Design	2050
Flow, (mgd)			
Average day	336	400	430
Peak day	573	731	782
Peak	845	930	930
BOD_5 (lb/day)			
Average	439,000	555,000	571,000
Peak	930,000	1,176,000	1,210,000
SS (lb/day)			
Average	374,000	511,000	
Peak	1,128,000	1,678,000	
Preaeration Channels			
Number Units	2	4	4
Detention time, min. (average day)	7.9	11.6	10.8
Primary Tanks			
Number units	8	14	14
Surface loading rate			
Average day	1,749	1,190	1,279
Peak day	2,983	2,174	2,326
Peak	4,399	2,767	2,767

The peak flow of 930 mgd for the year 2000 is apparently based upon the assumption that all the pumps at the Deer Island pumping station will be operating in the future. Subtracting peak flow from Winthrop pumping station, the maximum flow from the main pump station is 870 mgd. Although the Winthrop station presently has capacity of 180 mgd there is provided only 60 mgd capacity in the grit removal facilities and all flow in excess of this amount is by-passed to the Deer Island by-pass outfall.

In order to be able to pump 870 mgd through the main pumping station, EMMA recommends replacing all radial dual fuel engines that drive the pumping units with electric motors. While we concur that this is a high priority item, and it will decrease the necessity of throttling the headworks so frequently, the capacity will still be inadequate to prevent this necessity.

EMMA recommends adding six primary sedimentation tanks to reduce the average daily surface loading rate to 1190 GPD/SF at the flow to be expected in the year 2000. These additional tanks are not expected to significantly increase primary treatment capacity, only to improve degree of treatment.* The addition of tanks will bring the present excessive surface loading parameter down to usual design values.

Although we showed in Figure 2-3 that the treatment facility reports good performance at the high surface loading rate of 1750 GPD/SF (corresponding to a detention time of 60 minutes), treatment efficiencies must also be improved for the peak day flows. This will be especially important when the Nordberg engines are replaced with electric motors, enabling the main pump station to pump at rated capacity.

* (Size of tanks could be based either on flow, treatment desired, or both.)

The addition of the six settling tanks reduces the average daily surface loading rate from 1749 to 1190 GPD/SF. Although Figure 2-3 shows that removal efficiencies of BOD seem to be only minimally improved by increases in the hydraulic detention time, it is seen that settleable solids and suspended solids removals are quite sensitve to detention times. Thus, only small improvements in BOD removals compared to present performance can be expected, but definite improvements in solids removals should occur when the overflow rate is reduced to 1190 GPD/SF.

The EMMA Study recommends both expanding the preaeration channels and adding two new ones to increase the preaeration time of the waste. It is felt that the present detention times are inadequate to permit sufficient preflocculation to aid the settling process. Expansion of the preaeration capability is expected to aid in pollutant removals, and also to aid in scum removal.

The projected capital cost of the EMMA plan primary expansion of Deer Island is $41.9 million. This is based on an ENR Index of 2200, and includes a 35 percent allowance for engineering and contingencies. The annual operation and maintenance cost of the expanded primary facility is estimated to be $6.1 million. These costs relate to the following additions to the existing facility:

6 primary tanks
2 chlorine contact tanks
effluent pumping station
additional channels, conduits, galleries
additional outside piping, roads and grading
additional electrical work and instrumentation

Costs related to sludge management are not included in these estimations.

Although this chapter has focused upon the primary treatment conditions and only upon the primary treatment expansion and upgrading planned in the EMMA Study, we feel it is important to make one statement concerning secondary treatment plans in EMMA. Due to the high salinity concentrations and variations discussed in Chapter 6 and due to industrial waste flows and temperature variations evidenced at Deer Island, we recommend that pilot plant treatability studies using the activated sludge process be conducted early in the facilities planning process to determine its ability to withstand these variations.

b. The EMMA Recommended Plan with regard to primary sludge management, reference 2.17. The EMMA Study points out that a portion of the treatment efficiency of primary sedimentation is lost because the removed sludge is returned to the Harbor. Although the sludge is subject to anaerobic digestion prior to discharge, we have shown that even the digested sludge contains considerable quntities of BOD and solids.

The EMMA Recommended Plan proposes sludge disposal by incineration at a capital cost of $25.6 million as Priority Item No. 1 with completion scheduled for 1980. Design and construction of the facilities must await the completion and approval of the Environmental Impact Statement on sludge management. Discussion of sludge disposal alternatives will be covered by the Phase II consultant on sludge management.

B. NUT ISLAND SEWAGE TREATMENT PLANT

1. GENERAL DESCRIPTION

The Nut Island Sewage Treatment Plant is located in the City of Quincy at the north end of Houghs Neck, adjacent to Quincy Bay and the southern part of Boston Harbor. The plant treats wastewater collected from 21 cities and towns plus parts of Boston, Brookline, Milton and Newton as shown on Fig. 2-1. It serves an area of approximately 238 square miles and a population of about 634,000. The Nut Island Plant was designed for an average daily flow of 112 MGD (million gallons per day) and a peak flow-rate of 310 MGD according to the MDC. The plant has been in operation since 1952, reference 2.1.

a. South Metropolitan Sewerage System Pumping Stations. The MDC interceptor sewer system which transports wastewater from the Southern part of the Metropolitan Sewerage District to Nut Island Treatment Plant has the following pump stations:

Pumping Station	Rated Capacity (MGD)
Braintree-Weymouth	60.0
Hingham	4.2
Hough's Neck	2.8
Quincy	52.0
Squantum	8.0
	127.0

Each of these pumping stations serve areas having separated sewer and storm drain systems. These pumping stations are all over twenty-five years old, with the exception of Hingham. The Quincy Station is 74 years old and two of its pump units are 25 years old. The Squantum Station and pumps are 39 years old. The EMMA Study evaluated each facility and listed the immediate rehabilitation needs of these MDC pumping stations, reference 2.2.

The Braintree-Weymouth and Quincy Pumping Stations have bar screens. The EMMA Study recommends that an additional bar screen and cleaning mechanism be added to the Braintree-Weymouth Station, that one bar screen at Quincy be replaced and relocated, and that a bar screen with cleaning mechanism be installed at the Squantum Station. The bar screens at Braintree Weymouth and Quincy constitute the only preliminary treatment of wastewater ahead of the Nut Island Treatment Plant site.

b. Unit Processes at Nut Island. The treatment plant receives wastewater in headworks which provide screening, grit settling and collection, and maceration of solids by comminutors. The pretreated wastewater is pumped to aeration tanks for freshening. From these tanks, the flow passes through sedimentation tanks for removal of solids and floatables. The treated effluent is then chlorinated and discharged to Boston Harbor.

Sludge and skimmings from the sedimentation tanks are collected and pumped to primary digesters. Digested sludge is discharged to the Harbor on outgoing tides. Screenings and grit collected in the headworks are burned in a multi-hearth incinerator. Ash is slurried and pumped to the harbor with the effluent.

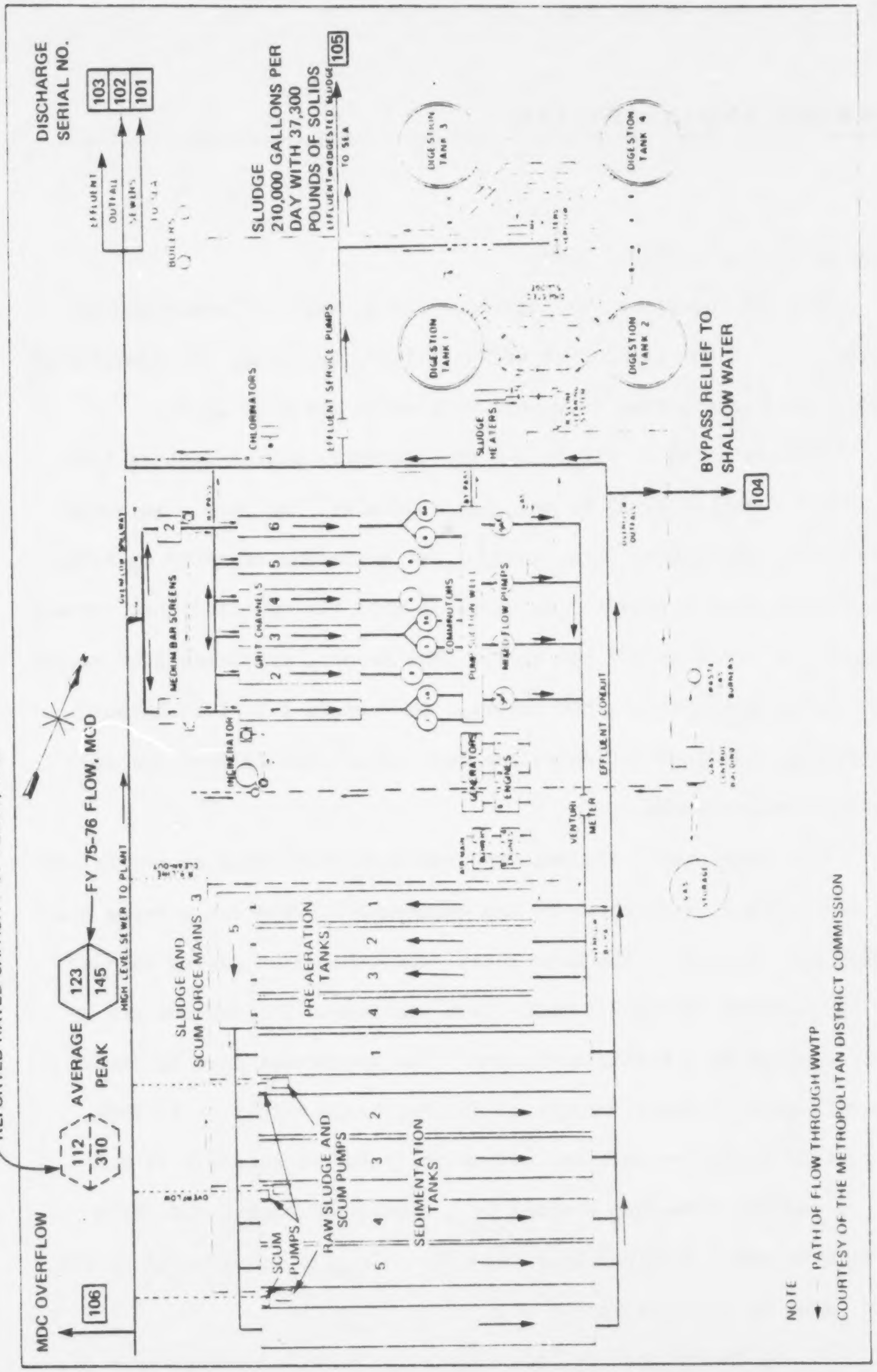
The following sections detail the major treatment unit processes and plant support facilities as observed in a visit to the facilities and review of the MDC plans and references 2.1, 2.4 and 2.18. Figure 2-5 provides a flow diagram of the treatment plant.

Most of the plant was completed and placed into operation in 1952 although some of the facilities at Nut Island, including the Administration Building and certain pipelines were originally built in 1905.

We have added to Figure 2-5 the discharge serial numbers from the NDPES Permit for the overflows and plant outfalls. We have also added the average flow, peak hourly flow, loading and emissions reported in reference 2.10, and the design capacity as rated by MDC. It is noted that present design capacity is rated at 127 mgd in the EMMA Report, reference 2.17 rather than at 112 mgd as rated in the MDC reports, references 2.1, 2.10 through 2.13. The average loadings and emissions for fiscal year 1975-76 and percent removals are also shown.

(1) Headworks. Preliminary treatment facilities at Nut Island consist of bar screens, grit chambers and comminutors. The bar screens and grit chambers are located in the Grit Room. The wastewater passes through two medium bar screens having 7/8-inch clear openings. The screens are mechanically cleaned by a raking mechanism. The wastewater flow is distributed among six grit channels, each being 80 feet by 10.4 feet by 15 feet deep. At average daily design flow, the velocity in the channels is 0.2 fps. Grit is removed from each channel by conventional bucket and chain apparatus with 80 cubic feet per hour capacity. Grit is transported to the incinerator area by conveyor belt.

A 36-ton per day, six-hearth incinerator accepts grit via a 25-cubic foot pneumatic grit ejector. Two 3-cubic foot pneumatic ejectors


REPORTED RATED CAPACITY OF PLANT, MGD
MDC OVERFLOW
106
112
310
AVERAGE
PEAK
123
145
FY 75-76 FLOW, MGD
HIGH LEVEL SEWER TO PLANT
SLUDGE AND SCUM FORCE MAINS 3
PRE AERATION TANKS
SCUM PUMPS
RAW SLUDGE AND SCUM PUMPS
SEDIMENTATION TANKS
VENTURI METER
EFFLUENT CONDUIT
ENGINES
GENERATORS
INCINERATOR
MEDIUM BAR SCREENS
GRIT CHANNELS
COMMINUTORS
PUMP SUCTION WELL
MAIN FLOW PUMPS
OVERFLOW CHANNEL
GAS STORAGE
WASTE GAS BURNERS
DIGESTION TANK 1
DIGESTION TANK 2
DIGESTION TANK 3
DIGESTION TANK 4
SLUDGE HEATERS
CHLORINATORS
EFFLUENT SERVICE PUMPS
BOILERS
EFFLUENT OUTFALL SEWERS TO SEA
DISCHARGE SERIAL NO.
103
102
101
SLUDGE 210,000 GALLONS PER DAY WITH 37,300 POUNDS OF SOLIDS
EFFLUENT AND DIGESTED SLUDGE TO SEA
105
BYPASS RELIEF TO SHALLOW WATER
104
NOTE
← PATH OF FLOW THROUGH WWTP
COURTESY OF THE METROPOLITAN DISTRICT COMMISSION

	BOD	SS	GREASE	CHLORINE	UNITS
INFLUENT	115,000	214,500	33,460		POUNDS PER DAY
EFFLUENT	125,000	116,000	23,100	1,330	POUNDS PER DAY
REMOVALS	17%	46%	31%		PERCENT

Basic Diagram from MSD

NSF Boston Case Study, Phase II Evaluation

NUT ISLAND FLOW DIAGRAM

Kennedy Engineers
1977

Figure **2·5**

feed screenings to the hearth. Air for the ejectors is supplied by an 80 CFM 125 psi air compressor.

Nine comminutors are housed in the Comminutor Room. The number of each size is listed and described as follows:

4 - Comminutors, 36" size, having 3/8" opening, 26 mgd cap. ea.
2 - Comminutors, 36" size, having 3/8" opening, 20 mgd cap. ea.
3 - Comminutors, 42" size, having 3/8" opening, 40 mgd cap. ea.

(2) Influent Pumps

The influent pumping station was designed to pump a peak flow rate of 300 mgd. The station contains four mix-flow vertical sewage pumps each with a rated capacity of 83.5 mgd at a discharge head of 10.3 feet. Two units are constant speed (190 rpm) and two are driven by variable speed motors. All four are driven by 200 horsepower electric motors with power supplied solely from in-plant generators.

Plant bypassing occurs by overflow of a weir in the High Level Sewer feeding the plant. These bypass flows are unmetered and unchlorinated. When flow exceeds the pumping capacity available, overflow is directly discharged through any one of three outfalls.

(3) Power Generation

The plant has no outside electrical service connection. All power for wastewater pumping and operation of plant equipment must be provided by the three engine-generator units. With one large generator out of service there is inadequate generator capacity to meet connected load demands.

Engine No. 1 can run on digester gas only. When gas supply is inadequate, the unit is inoperable. It is rated 850 HP and generates 750 KVA, 2300 volt power. Engines No. 2 and No. 3 are dual fuel units and can operate entirely on oil if necessary. One is rated at 820 HP and generates 750 KVA, the other is rated at 630 HP and generates 450 KVA. There are two other dual fuel engines that are direct connected to the preaeration blowers. These engines are 213 HP units.

(4) Pre-aeration System

The sewage flow discharged by the influent pumps passes through a 120-inch x 60-inch diameter Venturi meter and into the pre-aeration system. As shown in Figure 2-5, the flow is distributed between four parallel aeration tanks, all discharging into a fifth tank. The parallel tanks are 166 feet long by 21 feet wide by 14 feet deep. The final tank is 85 feet by 12 feet by 14 feet deep. At the average daily design flow of 112 mgd, detention time of the wastewater in the aeration tanks is about 15.5 minutes. The tanks are equipped with swing arm diffusers, designed to provide 0.1 cubic feet of air per gallon of wastewater treated.

The addition of air to the wastewater is to prevent the flow from turning septic and to aid in grease removal.

(5) Sedimentation Tanks

The pretreated wastewater flows by gravity from the aeration tanks and is distributed between six sedimentation tanks. Scum and grease are collected from the surface, while settleable solids are collected by longitudinal chain scrapers from the bottom of the tank.

Each tank is 185 feet long x 68 feet x 13 feet average water depth and is covered. At the average daily design flow with all tanks in service, the detention time of the wastewater in the sedimentation tanks is 94 minutes. The designed surface loading rate with all tanks in service at the average daily design flow is 1484 gallons per day per square foot of surface area.

The sedimentation tanks are equipped with a conventional sludge and scum collector system of chain driven flights. The tanks are set up in groups of two with a common sludge pumping house, and a scum pit for each tank. The scum is collected at the center of the settling tank by special paddle conveyors and then flows to a common draw-off system between the paired tanks. From there the scum flows to the scum pit at the head of the tanks. The sludge is collected along the bottom of the tanks and transported by the flights to the end of the tanks. Here a cross-collection system draws the sludge to a sludge well. It is then pumped to a common sludge pit ahead of the digesters.

Each of the three sludge Pumping Stations is equipped with two 300 gallon per minute (gpm), positive displacement plunger pumps for sludge and one torque-flow type pump for scum. By design, any pump house can pump from any tank, but the normal operating procedure is to pump from the house adjacent to its respective tanks.

(6) Chlorination System

The effluent from the treatment units is chlorinated at manually set rates to provide for disinfection. Provisions for pre-chlorination before the treatment units also exist and are employed during the summer months, principally for odor control.

Chlorine is stored at the plant's administration building in one-ton cylinders. Three storage bays exist, each providing storage space for 12 cylinders plus a scale holding three cylinders for use. Each bay also has a hoist used to handle the cylinders.

The liquid chlorine drawn from the cylinder is piped from the administration building to the power and pumping building where four chlorine evaporators are located. These evaporators can feed any of the four chlorinators located in this building. The units are each rated at 8,000 pounds of chlorine per day. The chlorine solution can be piped to either or both the pre- and post-chlorination points in the plant. Pre-chlorination can occur at a point in the influent line upstream of the bar screens. There is no provision for chlorination of the overflow by-pass ahead of the plant. Post-chlorination occurs downstream of the sedimentation tanks.

(7) Anaerobic Digesters

Primary sludge and scum are pumped intermittently during each day to the anaerobic digesters. The digesters stabilize the sludge by anaerobic digestion prior to its discharge. The methane gas produced by anaerobic digestion is used to run the electric generator engines, the plant's boiler, the incinerator and the air compressors.

There are four digesters at the plant. Each of the four digesters is 110 feet in diameter and 30 feet deep. Each digesters' capacity is 2.3 million gallons. Digesters No. 1 and No. 2 have fixed covers and are equipped with external recirculation and heat exchangers. Digesters No. 3 and No. 4 have floating covers and are mixed by a gas recirculation system. Each of the digesters is heated by a common heat exchanger.

Digested sludge is pumped to sea by two centrifugal pumps. During periods of no discharge, three small pumps continually discharge plant effluent through the sludge disposal line in order to keep sea water from backing into the system.

The digester gas collection system draws from all four digesters and feeds to the boiler unit in the administration building or to the gas control building. Gas fed to the gas control building can either be sent to the engines or the incinerator, or it is pressurized and stored in a 90,000 cubic foot capacity Hortonsphere at 30 psi. Any excess gas produced is burned by six waste gas burners.

(8) Plant Outfall System

There are three outfalls to transport plant effluent, and one that transports digested sludge to sea for disposal. In addition, there is a short relief outfall that is used during peak flows. There are also seven "active" bypasses and one "inactive" bypass of the Nut Island facility which use the plant outfalls with decreased treatment.

The plant outfall system was originally designed to discharge to the Nantasket Roads in the Outer Harbor through two long outfalls (5,830 feet and 5,545 feet). These pipes are five foot in diameter and their outlets are submerged about thirty feet. A third outfall is normally closed and is used in the event of extreme high tides or plant inflow in excess of 150 to 200 mgd depending on tidal conditions. This five foot diameter outfall is only 1412 feet long and its outlet is submerged about twenty feet. The plant is also provided with an overflow weir in the effluent conduit downstream of the sedimentation tanks, upstream of post-chlorination point. The outfall from this weir overflow conveys discharges to the eastern shoreline through a six foot diameter pipe to a point 468 feet off shore. This outfall functions when tides are extremely high and/or when plant inflows approach 300 mgd. During high tides, the pipe outlet would be submerged by about fifteen feet.

The digested sludge disposal line is 12 inch diameter and runs from Nut Island to Long Island and then to President Roads for discharge into deep water. This line is 4.2 miles long.

There are five bypasses at the following locations:

(a) Overflow spillway ahead of the inlet to bar screens.
(b) Between bar screens and grit channels.
(c) At pump suction wet well.
(d) At inlet to aeration tanks.
(e) Three overflows at scum sumps.
(f) Effluent conduit (outfall to Hingham Bay).

None of these bypasses or overflows can be metered. Bypasses (a) through (e) discharge via the effluent outfall system except when it is surcharged, during which time the excess flow spills out bypass (f). Bypass (c) is apparently no longer active and is the only one that can be chlorinated. Bypasses will occur at (a) when flow exceeds 250 mgd during high tide, when the plant is shut down, or when the bar screen is inoperative for more than four hours at flows above 150 mgd. Bypasses at (b) occur when the capacity of the grit channels and/or the mixed flow pumps is exceeded. At location (d), bypasses occur at flows exceeding 200 to 220 mgd.

2. DISCHARGE REQUIREMENTS

The effuent restrictions and monitoring requirements for the Nut Island Treatment Plant are stated in the NPDES permit for the MDC, issued on August 12, 1976 reference 2.5. Effluent limitation are presented in two categories; those applying until June 30, 1977, and those that Nut Island must comply with after that date.

a. Effluent Limits

The Nut Island Treatment Plant is authorized to discharge from its three main plant outfalls:

> "an effluent to Boston Harbor/Quincy Bay whose concentration and combined loading shall not exceed the values listed below:

Effluent Characteristic	Monthly Average	Weekly Average	Maximum Day
Flow, (mgd)	*	-	-
Biochemical Oxygen Demand 5-day, 20°C	248,000 lbs/day 165 mg/l	180 mg/l	200 mg/l
Total Suspended Solids	210,000 lbs/day 140 mg/l	150 mg/l	195 mg/l
Settleable Solids	-	-	1.0 ml/l
Fecal Coliform Bacteria	Provide continuous chlorination		
Total Coliform Bacteria	Provide continuous chlorination		

*For any consecutive 12 month period, the average quantity of effluent discharged shall not exceed 180 mgd."

The NPDES permit also stipulates the following requirements:

> (1) The minimum percent removals of biochemical oxygen demand and total suspended solids shall be 22 percent and 44 percent respectively, based on a twelve consective monthly average of influent and effluent concentrations of the two parameters.
>
> (2) "The pH of the effluent shall not be less than 6.0 nor greater than 9.0 at any time unless these values are exceeded due to natural causes or as a result of the approved treatment processes."
>
> (3) "The total chlorine residual of the effluent shall not result in any demonstrable harm to aquatic life or violate any water quality standard which has been or may be promulgated."
>
> (4) "The discharge shall not cause visible discoloration of the receiving waters after appropriate mixing."

Until completion of new sludge disposal facilities, digested sludge may be discharged from the Nut Island facility into Boston Harbor only during the four hour period beginning at high tide.

Until expiration of the permit on May 1, 1981, Nut Island may discharge from its emergency outfall into Hingham Bay during periods when the influent flow rate exceeds 250 mgd and/or during periods of abnormally high tides. All discharges shall receive preliminary screening and disinfection and when a discharge from the emergency outfall occurs or is anticipated, the permittee shall prechlorinate the influent wastewaters to the plant. Furthermore, discharges from the emergency outfall which include any waste that has not been treated in the sedimentation basins, shall be reported to the EPA. During the months of May through September, the Quincy Commissioner of Public Health shall also be notified of such occurrences.

b. Monitoring and reporting requirements. There are three groups of monitoring and reporting requirements placed upon the Nut Island treatment plant.

(1) The quantity and quality of the effluent discharges must be monitored and recorded. The NPDES permit enumerates the parameters to be measured, the minimum frequency of the analyses and the type of sample to be collected (grab sample vs. composite sample). Quality of the plant influent must be recorded in some instances also.

(2) Nut Island shall also monitor and record the quantity and quality of discharges of digested sludge. The permit again enumerates the parameters to be measured, the frequency of analysis, and the sample type to be obtained. BOD and coliform analyses are not required.

(3) Whenever discharge occurs from the plant's emergency outfall, the flowrate, fecal and total coliform counts, and the chlorine residual are to be monitored at least once per each eight hours or less of discharge. A recorder is to be installed to indicate when the outfall is being used.

3. EFFICIENCY OF TREATMENT AT NUT ISLAND

As in the case of the Deer Island Treatment Plant, the Nut Island Facility will be examined in three steps. First, performance over the period of July 1975 through June 1976 will be examined. This will be followed by comparisons of these data with the data for four prior years. The final comparison of performance will be against the NPDES permit requirements.

a. Performance during the period of July 1975 through June 1976.

The MDC made available their monthly data reports on the influent, effluent, and sludge characteristics analyzed at Nut Island for the fiscal year 1975-1976, reference 2.19. These reports included data on the temperature, pH, flow rate, coliform counts, solids and BOD content of the influent sewage. They also reported effluent concentration of BOD and solids and coliform counts. Records of chlorine dosage rates and volume of grit removed were also kept. Additional data sheets provided data on raw and digested sludge flow rates, solids content and pH. These also reported digester gas production.

Since the basic objectives of primary treatment at Nut Island are to reduce the BOD, suspended solids and settleable solids content of raw sewage through settling and to reduce coliform concentrations by disinfection, the major emphasis of the evaluation of the Nut Island data sheets will be focused upon the efficiency of the sedimentation tanks and related sludge disposal facilities.

Table 2-7 summarizes data related to the sedimentation tank performance. The data are summarized by month. Daily flow to Nut Island is listed on a per sedimentation tank basis since the number of tanks in service was found to vary significantly. The reported values include the minimum and maximum total daily flow occurrences, plus the average daily flow for the month. During the month of December the number of tanks in service each day was not reported. Using the influent and effluent concentrations of settleable solids, BOD and suspended solids, the average monthly percents of pollutant removals were reported by the MDC for Nut Island and are summarized in Table 2-7.

Based upon the size and geometry of the sedimentation tanks designed at Nut Island and upon the maximum, minimum and average daily flows per tank, the various detention times and surface loading rates were calculated and reported in Table 2-7.

Sedimentation tanks are normally designed now on the basis of average surface loading rate. The correlation between the surface loading rate and hydraulic detention time for the Nut Island sedimentation tanks is presented in Figure 2-6. The Figure also displays the ranges of average daily flows per tank, detention times and surface loading rates achieved at Nut Island during fiscal year 1975-76. The design values of these parameters are indicated as well on the Figure, based upon the average daily design flow rate of 112 mgd as rated by the MDC, with all six sedimentation tanks in service. The design points are 18.67 mgd per tank, approximately 94 minutes of detention and a surface loading rate of about 1480 gpd/square foot. At a flow of 21.2 mgd per tank as rated in the EMMA Report, the detention time would be 83 minutes and the surface loading would be 1680 gpd/square foot, with less removals expected.

During the 1975-76 fiscal year, Figure 2-6 shows that the average daily flow per tank exceeded the design flow. This condition resulted primarily from the limited number of tanks in service throughout the year. Table 2-8 presents a monthly accounting of the number of days per month that

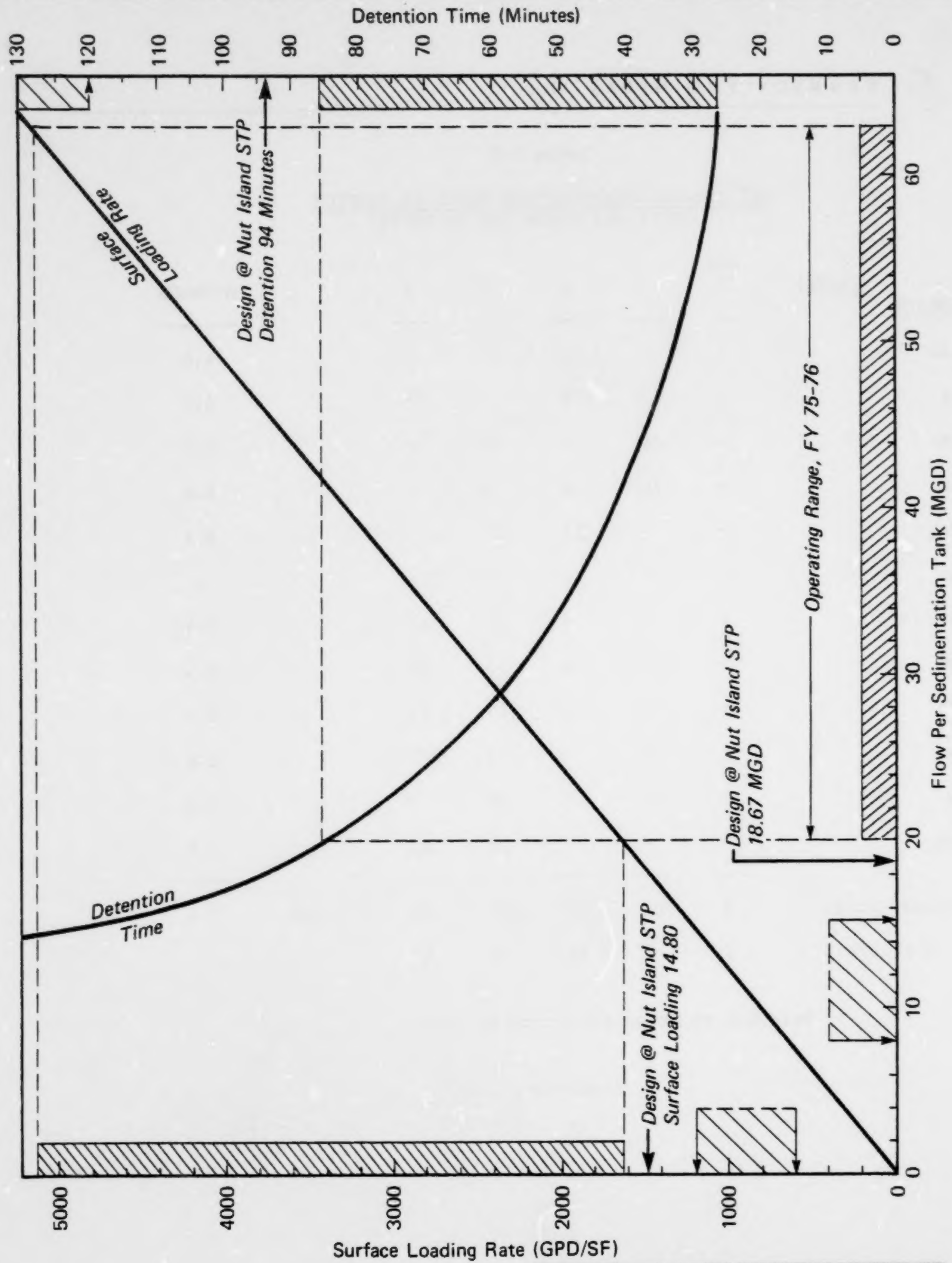
Table 2-7

NUT ISLAND PLANT PERFORMANCE
(July '75 - June '76)

MONTH	DAILY FLOW *(MGD)			AVERAGE CONSTITUENT REMOVAL (%)			DETENTION TIME (Minutes)			SURFACE LOADING RATE (gpd/ft^2)		
	MIN.	MAX.	AVE.	SETTL. SOLIDS	BOD$_5$	SUSP. SOLIDS	MIN.	MAX.	AVE.	MIN.	MAX.	AVE.
7/75	29	35	30	90.0	17.7$^{\Delta}$	49.5	49	60	57	2380	2870	2460
8/75	20	38	30	91.7	18.7$^{\Delta}$	49.3	45	85.5	57	1640	3110	2460
9/75	26	49	35	90.2	18.8$^{\Delta}$	44.8	35	67	60	2130	4010	2870
10/75	24	51	30	93.7	18.9$^{\Delta}$	50.5	33.5	71	57	1970	4180	2460
11/75	34	50	40	78.9	15.6	39.8	34	50	43	2790	4100	3280
12/75	# of tanks in use not reported.			87.0	21.0	47.2	-	-	-	-	-	-
1/76	45	63	50	70.6	15.6	40.8	27	38	34	3690	5160	4100
2/76	29	60	39	88.6	18.2	40.7	28.5	59	44	2380	4910	3190
3/76	27	56	38	90.0	18.7	43.4	30.5	63	45	2210	4590	3110
4/76	30	44	39	85.6	15.8	43.8	39	57	44	2460	3600	3200
5/76	30	46	40	85.5	18.6	50.0	37	57	43	2460	3770	3280
6/76	40	61	44	81.6	13.2$^{\Delta}$	44.7	28	43	39	3280	2000	3600
AVERAGE	-	-	38	86.1	17.6	45.4	-	-	47.5	-	-	3090

* PER TANK FOR DAYS BOD$_5$ IS REPORTED. $^{\Delta}$Pre-chlorination in effect, influences BOD values.

(Reference 2.19)



▨ Values Realized at Nut Island (Ref. 2.19)

▨ Typical Design Values (Ref. 2.7)

NSF Boston Case Study, Phase II Evaluation

NUT ISLAND SEDIMENTATION
TANK CHARACTERISTICS

Kennedy Engineers
1977

Figure **2·6**

Table 2-8

NUT ISLAND SEDIMENTATION TANKS IN SERVICE
(DAYS PER MONTH FOR FY 75-76)

MONTH	TANKS: ALL 6	5	4	3	2		AVERAGE
July '75	-	-	31	-	-		4.0
Aug	6	-	25	-	-		4.4
Sept	-	10	-	20	-		3.7
Oct	-	19	4	8	-		4.4
Nov	-	-	13	17	-		3.4
Dec*	-	-	-	-	-		-
Jan '76	-	-	-	14	17		2.4
Feb	-	-	6	13	10		2.9
Mar	-	-	4	13	14		2.7
Apr	-	-	-	23	7		2.8
May	-	-	-	31	-		3.0
June	-	-	-	20	10		2.7
Annual Total:	6	29	83	159	58	$\Sigma = 335$	3.3
% of Total:	2	9	25	47	17		

* Data not reported for December 1975.

(Reference 2.19)

any given number of sedimentation tanks were in service. It should be noted that 64 percent of the time, the plant operated with three tanks or less in service. Only one third of the time was the plant above half capacity in service. Also, since the average daily flow for that year was in excess of the design flow by 10 percent, the range of flow per tank was on occasion as much as three times the design capacity (see Figure 2-6). The average flow per tank at Nut Island for the 1975-76 fiscal year was 38 mgd per Table 2-7. This is twice the design value.

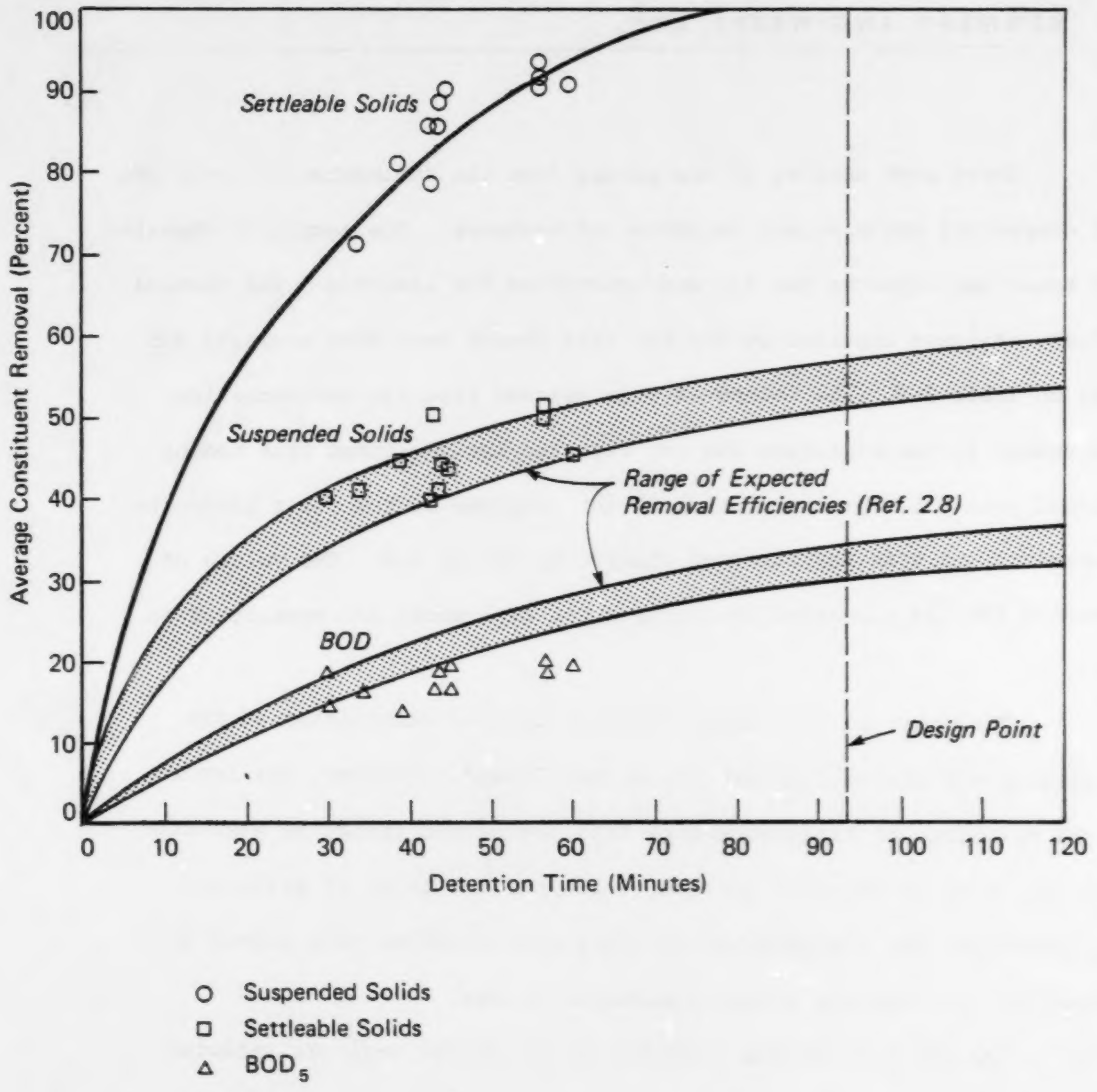
The causes of the poor service record of the sedimentation tanks will be discussed later in the chapter. It is important, however, to note that the Nut Island sedimentation tanks are covered and their scraping equipment operation is not hindered by snow or ice conditions, unlike the Deer Island tanks.

As shown in Figure 2-6 and Table 2-7, the overloading of the sedimentation tanks resulted in average daily detention times as low as 27 minutes (January 1976), and corresponding surface loading rates as high as 5160 gpd/square foot. These values are based on average daily flow of the peak day. The average surface loading rate for the year exceeded the design by 100 percent. If all of the tanks were kept in operating condition, the average surface loading rate would have exceeded the design by only 10 percent, due to the influent flow rate exceeding the design rate.

Figure 2-6 includes a plotting of typical surface loading rate design values as discussed in more detail for Deer Island. Using such rates, the corresponding detention times exceed 120 minutes for the specific size and geometry of the Nut Island tanks. The flow rate per tank would be reduced to between about 8 and 15 mgd.

As presented more fully for Deer Island, effectively designed and operated primary sedimentation tanks should remove 25 to 40 percent of the BOD and 50 to 65 percent of the suspended solids, reference 2.7. The settleable solids content should be virtually all removed. Table 2-7 shows that during fiscal year 1975-76, the Nut Island Treatment Plant removed 86%, 18% and 45% of the influent settleable solids, BOD, and suspended solids, respectively. These values are annual averages with monthly and daily removals varying greatly from these annual means.

The average monthly percent removals of these constituents are plotted against detention time in Figure 2-7. As in the case of Deer Island, the values indicate that greater removals are obtainable during longer detention times. Also plotted on the Figure are the expected removal ranges for BOD and suspended solids versus detention times for wastewaters of similar pollutant strength. It should be noted that the Nut Island facility is apparently below the expected effectiveness in removal of BOD under present loading conditions. The plot indicates expected removal of suspended solids is being achieved at present loadings. Unfortunately, since the sedimentation tanks were consistently overloaded, no data points are available to show what removals would have been at the design detention time of 94 minutes. It would be expected, however, that marked improvement in removal efficiencies could be attained if the facility was operated at the design values.



NSF Boston Case Study, Phase II Evaluation

TREATMENT EFFICIENCIES
AT NUT ISLAND STP
(Monthly Averages, 7/75 - 6/76)

Kennedy Engineers, Inc. Figure **2·7**
1977

Three grab samples of raw sludge from the sedimentation tanks are taken and composited daily except holidays and weekends. One sample of digested sludge is taken per digester per day and composited for analysis. The results of the sludge analyses reported on the MDC data sheets have been averaged and summarized on Table 2-9. The volume of scum removed from the sedimentation tanks and pumped to the digesters was not reported for the first nine months of the fiscal year. Sludge supernatant is not returned to the plant headworks but is pumped to sea with the digested sludge, reference 2.4. The volume of gas production for the digesters is averaged for each month and summarized in the Table.

The scope of this study does not include examination of the sludge digestion and disposal operations at Nut Island. However, the importance of the discharge of digested sludge into the Harbor cannot be neglected in this study, since it directly influences the present level of pollutant loading. Therefore, the available sludge data were examined with regard to solids content of the digested sludge discharged to sea.

The MDC data sheets provided on the sludge analyses included flow data and solids content data but no evaluations of the BOD of the digested sludge. The BOD of sludge is not normally determined and therefore, very little data are available to help estimate the concentration at Nut Island. We were able to locate one source of data which reported estimated summer waste discharges from the Deer and Nut Island plants, including BOD mass emission values, reference 2.9. The reported values covered the years of 1967 through 1969. From the data it was estimated that the BOD of the Deer Island sludge

* NO. 4 DIGESTER NOT METERED
BUT CALCULATED)

Table 2-9

NUT ISLAND - SLUDGE CHARACTERISTICS

MONTH/YR	INFLUENT TO DIGESTERS			EFFLUENT TO OUTFALL			GAS PRODUCED (1000 FT^3/DAY)
	SLUDGE FLOW (1000 GAL/DAY)	VOLATILE SOLIDS CONTENT(%)	VOLATILE SOLIDS (% of T.S.)	SLUDGE FLOW (1000 GAL/MO)	TOTAL SOLIDS CONTENT(%)	VOLATILE SOLIDS (% of T.S.)	
July '75	244	5.7	71.7	227	2.1	57.5	590
Aug '75	292	6.1	77.6	272	2.8	58.4	667
Sept '75	279	5.8	77.1	264	2.3	55.8	655
Oct '75	267	5.3	77.4	260	2.8	57.3	573
Nov '75	224	5.5	78.1	220	2.2	56.7	518
Dec '75	246	4.7	79.7	237	2.3	58.8	510
Jan '76	156	4.4	80.3	150	2.5	54.8	279
Feb '76	184	4.3	80.1	175	1.0	59.1	190
Mar '76	179	4.4	80.1	174	0.6	63.1	29
Apr '76	178	5.1	80.6	170	2.1	59.5	121
May '76	254	4.6	79.7	248	2.9	63.5	304
June '76	222	5.6	80.0	209	2.0	60.4	343
AVERAGE	227	5.1	78.5	217	2.1	58.7	398

varied from about 27,000 mg/l to 37,00 mg/l. The Nut Island sludge BOD values were less than ten percent those of Deer Island, according to the available data. The average value for those three years was about 2500 mg/l of BOD in the Nut Island sludge. [BOD of the sludge should be confirmed by the Phase II Sludge Consultant.] Using this value and the average daily sludge discharge volumes, it is possible to estimate a value of pounds per day of BOD discharge in the sludge. By adding this discharged quantity of BOD to that in the plant effluent, it is possible to adjust the daily average removal percentage values of each month to reflect the true overall discharge loading based upon the current sludge discharge practices at Nut Island. Table 2-10 reveals that during the fiscal year 1975-76, the Nut Island Plant in actuality removed only 14.6 percent of the influent BOD loading before discharging the wastewaters to the Harbor. This is 17 percent less effective than that reported if the sludge discharge is not considered (14.6% vs. 17.6%).

A similar evaluation of the overall plant efficiency can be made using the pounds of solids discharge in the effluent and sludge as compared to the influent values. This involves the suspended solids content (which includes settleable solids) of the influent and effluent and the solids content of the digested sludge discharge. Since the MDC data provided monthly totals on the sludge solids, Table 2-11 was generated on a total pounds per month basis. The monthly average values were also converted to daily average and presented at the bottom of the Table.

The major conclusion drawn from Table 2-11 is that when the digested sludge solids waste load discharged to the sea is added to that of the

Table 2-10

NUT ISLAND BOD REMOVAL EFFICIENCY
(Pounds per day for FY '75 - '76)

Month	BOD Influent	BOD Effluent	BOD Sludge[Δ]	Overall % Rem
July '75	171,700	141,300	4800	14.9
Aug	163,800	133,100	5600	15.3
Sept	189,000	153,900	5400	15.7
Oct	145,000	117,300	5400	15.4
Nov	143,400	121,100	4600	12.4
Dec	137,800	108,800	4800	17.6
Jan '76	111,900	94,500	3100	12.8
Feb	102,500	83,800	3800	14.5
Mar	122,300	99,400	3500	15.9
Apr	147,200	124,000	3500	13.4
May	172,200	140,200	5200	15.6
June	200,000	173,300	4400	11.2
DAILY AVERAGE:	150,600	124,200	4500	14.6

[Δ] Using 2400 mg/l BOD in sludge based on Hydroscience Estimate (reference 2.9)

Table 2-11

NUT ISLAND SOLIDS REMOVAL EFFICIENCY
(Pounds Per Month for FY '75 - '76)

MONTH	INFLUENT	EFFLUENT	DIGESTED SLUDGE	OVERALL % REMOVED
	Suspended Solids	Suspended Solids	Total Solids	
July '75	7,075,000	3,569,000	1,230,000	32.2
Aug	7,501,000	3,800,000	1,931,000	23.6
Sept	8,360,000	4,617,000	1,508,000	26.7
Oct	7,069,000	3,500,000	1,888,000	23.8
Nov	6,560,000	3,951,000	1,192,000	21.6
Dec	6,673,000	3,524,000	1,427,500	25.8
Jan '76	4,838,000	2,864,000	997,950	20.2
Feb	4,052,000	2,404,000	441,000	29.8
Mar	4,583,660	2,592,000	85,500*	41.6
Apr	5,860,000	3,291,000	868,000	29.0
May	7,947,000	3,973,000	1,833,000	26.9
June	8,076,000	4,462,000	1,038,000	31.9
AVERAGE/MONTH:	6,549,600	3,545,600	1,203,000	27.5
AVERAGE/DAY:	214,700	116,200	39,400	27.5

* Digesters inactive due to no heat when power out of service during part of month.

effluent in determining the overall effectiveness of Nut Island the percent of solid removed decreased to 27.5 percent. Relatively speaking, this is 40 percent less efficient than that summarized in Table 2-7 where the sludge discharge was not included (27.5% vs. 45.4%).

It should be noted that the sludge discharge from Nut Island has been restricted to only the four hour period following high tide. Therefore the daily loadings reported in Tables 2-10 and 2-11 do not reflect the much higher rate of discharge used during the intermittent discharge periods. It would be expected that daily discharge rates would average 118,200 pounds solids per day during the eight hours of discharge allowed daily. This rate is slightly larger than the average rate of plant effluent solids emissions (116,200 pounds/day).

In conclusion, the Nut Island treatment plant has been operating in an overloaded condition during the fiscal year 1975-76. The average daily flow of 123 mgd is 10 percent above the design value. Even more important is the fact that the average number of sedimentation tanks in service was only 3.3 out of a total of six. The resultant average overflow rate was nearly twice the design value and the detention time correspondingly very low. Under such high loadings only marginal primary treatment effectiveness was obtainable. Notably poor removal of BOD was attained during the year. Since the raw sludge removed from the wastewater is digested and then discharged to sea, the actual effectiveness of the Nut Island plant to reduce the pollutional loading on the Harbor is reduced. The overall effective BOD and suspended solids reduction are estimated at 14.6 percent and 27.5 percent, respectively, during that year.

b. *Performance from July, 1971 through June, 1975*. Every year, the MDC's Sewerage Division publishes an annual report detailing the operations of the Division, including the Nut Island treatment plant. A summary of the plant's performance during the reported fiscal year is presented. For comparative purposes, a portion of the data presented in four of the more recent reports is provided in Table 2-12, references 2.1, 2.11-2.13. The average values generated from the 1975-76 data sheets are also presented for comparison, reference 2.19. Since the annual report for fiscal year 1975-76 has recently been published (following the data evaluations in the previous section), the MDC reported values for that year are provided parenthetically below the already calculated values. By comparison, no significant differences exist, although the reason for any differences at all is unclear.

The Table indicates that during each of the last five years the plant has been overloaded (greater than 112 mgd). The performance during 1975-76 indicated a significant decline in BOD and settleable solids removal as compared to previous years, despite the somewhat lower flow rate. This is probably a direct result of the poor tanks-in-service record during 1975-76.

The sludge data presented for the fiscal year ending 1973 is clearly inconsistent with data for the other years. No explanation for the extreme differences is revealed by any other reported data for that year.

Using data within the annual reports it was possible to determine the overall efficiency of the treatment plant to remove solids. This overall percent removal is based upon the plant effluent concentration and flow plus the digested sludge emissions, The values of overall removal are presented

Table 2-12

NUT ISLAND ANNUAL PERFORMANCE COMPARISON

		FISCAL YEAR ENDING				
		1972	1973	1974	1975	1976*
PLANT EFFLUENT	AVERAGE DAILY EFFLUENT FLOW RATE (MGD)	128	144	139	138	123 (123)
	% REMOVAL SUSPENDED SOLIDS	46.7	44.5	54.4	48.5	45.4 (45.9)
	% REMOVAL BOD_5	23.9	24.6	29.0	21.2	17.6 (17.0)
	% REMOVAL SETTLEABLE SOLIDS	93.9	90.3	94.9	92.5	86.1 (87.0)
	% KILL OF COLIFORM BACTERIA	>99.9	>99.9	>99.9	>99.9	(>99.9)
SLUDGE	AVERAGE DAILY DIGESTED SLUDGE (MGD)	-	0.0008	0.3	0.2	(0.2)
	(1000#/DAY)	43.0	0.5	46.6	41.9	(36.9)
	TOTAL SOLIDS CONTENT (%)	2.0	7.0	2.1	2.2	(2.1)
	VOLATILE SOLIDS CONTENT (%)	-	52.5	58.8	57.3	(58.7)
	OVERALL % REMOVAL SUSPENDED SOLIDS	26.6	-	38.5	30.4	27.5

References 2.1, 2.10-2.13

* Values in ( ) are from MDC Annual Report for 75-76. Other values are computed from data sheets 1975-76.

at the bottom of the Table. A determination of a value for 1973 was omitted due to the questioned credibility of the sludge data of that report.

Poor performance is also indicated by the parameter of either soluble floatables or grease, Only 30.8 percent is reported as removed during fiscal year 1975-76. A well performing primary plant is normally expected to remove two-thirds to three-quarters of the grease.

The Nut Island annual report gives average annual bacterial concentrations by the millipore Filter Method of 13,400,000/100 ml. for the influent and 600/100 ml. for the effluent (not including sludge or by-passes). The average mass emission rate of the effluent, not including sludge and by-passes, amounts to 2.8 x 10^{12} per day.

An average chlorine residual of 1.3 mg/l in the effluent is reported. This amounts to 1,300 pounds per day of chlroine discharged. The NPDES permit does not stipulate a numerical value for maximum chlcrine residual in the effluent. However this residual can be expected to be rapidly dissipated in the receiving water prior to causing significant adverse effects. It is noted however in "Quality Criteria For Water" EPA 26 July 1970 that:

> "oysters are sensitve to chlorine concentrations of 0.01 to 0.05 mg/l."

c. Performance in comparison with NPDES permit requirements. In a previous section in this chapter, the NPDES permit for the Nut Island Sewage Treatment Plant issued August 12, 1976, has been discussed. The intent of this section of the chapter is to compare the Nut Island performance during the 1975-76 fiscal year with the NPDES permit requirements. Although some of the requirements in this new permit may not have been effective during the 1975-76 period, the comparison is appropriate because the requirements appear to be based upon reported historical plant performances.

The data sheets provided by the MDC included daily quality data for some parameters for about 240 days. Test results for holidays and weekends were missing. The NPDES permit definition of weekly average and monthly average do not reuqire daily monitoring. We used normal calendar determinations of weeks and months and averaged the provided data for all the days reporting within these specific time periods. Based upon this interpretation and the MDC data sheets reference 2.19, Table 2-13 was developed to show how Nut Island would have performed in comparison with the permit requirements now in effect.

Clearly a primary deficiency indicated in Table 2-13 is that the plant exceeded settleable solids effluent limitations about 42 percent of the time. Also, the minimum annual percent removal of BOD clearly was not achieved. The overloaded condition at Nut Island clearly deserves immediate attention. This will be dismissed further later in this chapter.

4. KENNEDY ENGINEERS' OBSERVATIONS OF FACILITIES

Various MDC facilities were visited during the period of September 27 to October 8, 1976. The following discussion summarizes our major observations of the facilities, followed by a listing of various deficiencies noted.

Like the Deer Island plant, the Nut Island plant is a primary plant using sedimentation tanks for solids removal. As such, the efficiency of wastewater treatment is related primarily to the sedimentation tank's surface

Table 2-13

NUT ISLAND PERMIT COMPLIANCE
(FY 1975-76)

VARIABLE	UNITS	EFFLUENT LIMITATION (1976-77)				NO. AVERAGING PERIODS AVAIL.	APPARENT VIOLATIONS
		DAILY	WEEKLY	MONTHLY	YEARLY		
FLOW	MGD	-	-	-	180	1	0
BIO. OXYGEN DEMAND 5-day, 20°C	mg/1	200	-	-	-	240	4
	mg/1	-	180	-	-	52	2
	mg/1	-	-	165	165	12	0
	lbs/day	-	-	248,000	-	12	0
	% removal	-	-	-	22	1	1
TOTAL SUSP. SOLIDS	mg/1	195	-	-	-	238	2
	mg/1	-	150	-	-	52	6
	mg/1	-	-	140	-	12	2
	lbs/day	-	-	210,000	-	12	0
	% removal	-	-	-	44	1	0
SETTLEABLE SOLIDS	ml/1	1.0	-	-	-	240	101

Fecal Coliform Bacteria - Provide continuous chlorination.................................0

Total Coliform Bacteria - Provide continuous chlorination.................................0

loading rates and hydraulic efficiencies.

A review of construction drawings indicates that the design of the tanks at Nut Island provided good inlet and outlet conditions which would be expected to distribute flows quite uniformly over the cross-sections of the tanks. However, differential settlement of the tanks appears to have affected flow distribution at effluent weirs.

Field inspections indicated that outlet conditions have been adversely affected by unequal settling of the tanks. However, we were advised that the weir displacement was within limits that would permit correction, and that a program of plant rehabilitation includes future plans for leveling the effluent weirs to restore good flow distribution. This badly needed work was not yet started in the fall of 1976.

The plant includes many supplemental process systems, such as pumping, screening, energy production, incineration of scum, sludge digestion and handling, and chlorination systems, some of which are quite complex, and are in varying states of disrepair. These supplemental systems can affect the effluent quality. However, the efficiency of sludge digestion and means of disposal directly affects water quality in the Harbor, because this sludge is discharged into the Harbor.

a. Basic objectives to be accomplished. To obtain maximum effectiveness of the Nut Island plant, the following basic objectives should be accomplished:

(1) Expedite the rehabilitation of the primary sedimentation tanks (the heart of the treatment process). This work should include leveling effluent weirs.

By keeping at least five of the six existing sedimentation tanks in service at all times, the present Nut Island pollution emissions discharged to the Harbor could possibly be reduced by ten to twenty percent. This is based upon increased detention times and reduced surface loading rates possible when more tanks are in service. It would also reflect improved performance through minimizing short circuiting by correcting the effluent weir problems.

(2) The sedimentation tanks at Nut Island have high surface loading rates and low detention times in comparison to conventional design tanks. The present flow rate also exceeds the original design criteria. The plant is overloaded particularly when one or more tank is out of service. This occurred about 98 percent of the time in FY 1975-76. A program to improve treatment efficiency should be undertaken by either adding more tanks, by diverting tributary flows, or otherwise reducing the inflow to the plant.

(3) Present sludge handling, digestion and disposal practices result in a significant pollution loading to the Harbor. Changes in the sludge disposal method, such as installation of sludge incineration, may make the single most significant reduction on waste load discharged. The present total solids discharged to the Harbor by the Nut Island plant could be reduced by about 24 percent if sludge were not discharged.

(4) The short emergency relief outfall should be extended to discharge in deeper off-shore waters near the existing two main outfalls. Chlorination should be provided on all overflows and bypasses. All three outfalls should then be used at all times to increase the chlorination contact time and to reduce plant bypasses. The use of multiple outfalls also results in spreading the concentration of the effluent into the receiving water.

(5) The chlorination facilities at Nut Island should be altered. Chlorine storage in the Administration Building is a dangerous practice. Chlorine storage should be in a separate building and only chlorine solutions should be distributed. Chlorine dosage rates is set manually at present. Equipment for automatic dosage control should be provided, plus standby units. Finally, the adequacies of chlorine diffusion, mixing and contact time in the effluent channel and outfall are questionable and should be examined further.

(6) Develop and implement a program to repair and modernize the plant in general, including rehabilitation of all supplemental process systems.

(7) A standby power source to assure continuous and reliable plant operation should be provided.

Items 1 and 2 above consider the deficiencies of the sedimentation tanks at Nut Island. The following methods could be considered for interim improvement to treatment plant performance.

(a) Preventive maintenance of sedimentation tanks. A primary cause of the poor quality effluent is the overloading of the sedimentation tanks due to tanks out of service. Routine preventive maintenance would help avoid unscheduled tank shut-down. When more than one tank is out of service, severe overloading results with significant deterioration in effluent quality. During the 1975-76 fiscal year, nearly half of the units were out of service on the average.

(b) Chemical addition to improve sedimentation. The use of chemical additions was discussed in the Deer Island section of this chapter. While, in the case of Deer Island, the potential advantages of various chemical additions were suggested for further study, at Nut Island there has been one documented demonstration of chemical addition to improve sedimentation.

The Calgon Corporation performed a Primary Flocculation Demonstration at the Nut Island plant during March through July, 1971. They reported a summary of their results and conclusions to the Massachusetts DWPC in August 1971, in fulfillment of a Demonstration Grant, reference 2.20. The demonstration involved four trial periods using anionic polymer addition to the plant influent stream (exact dosage point not mentioned in report). Results of the suspended solids removals occurring during these trail periods were compared with removal during pre- and post- polymer feed periods of plant operation. The general conclusions of the study are as follows:

> (i) "The greatest utility of the anionic polymer feed is in periods of hydraulic overload. For the Nut Island Plant, given a proper permanent feed system, 8-10% improvement in suspended solids removal can be effected using 0.1 ppm polymer feed during plant flow rates of 110-140 mgd. When water temperatures are low and viscosity is high, the optimum hydraulic overload for applying polymer might be 100-130 mgd."

> (ii) "Probably the greatest portion of suspended solids agglomerated into floc particles are those which would be large enough to settle without polymer, if the plant were not hydraulically overloaded."
>
> (iii) "To effect any appreciable removal of submicron-colloidally dispersed particles with highly anionic charge densities by bridging would require anionic polymer feed rates many orders of magnitude higher. In short, for the conditions studied at Nut Island, the "point of diminishing returns" for anionic polymer feed is the 0.1 ppm required to bridge and agglomerate normally settleable solids."
>
> (iv) "There may be times, such as encountered during the second trial, when hydraulic overload is occurring but the chemical and physical properties of the sewage inhibit good results with the polymer. Perhaps this is related to some unusual quantity or quality of an industrial waste input to your collection system."
>
> (v) "Typically, in the four polymer trials made to date, the removal of an "extra" 10 mg/l of the suspended solids (about 5% improvement) with 0.1 ppm anionic polymer results in an "extra" 5 tons of sludge (dry basis) removed per day for about $120. With optimum polymer feed, and approaching 10% improvement with 0.1 ppm polymer, an extra 10 tons of sludge would be removed per day for about $120."

The Calgon report did not state how it was determined that only one anionic polymer was to be used in the demonstration. Usually anionic, cationic and non-ionic polymers of several types as well as aluminum and iron salts that are compared alone and in various combinations are tested on wastewaters to determine optimum chemical additive and dosage. The results of tests with just one additive appear to indicate a potential for effecting increased removal efficiency at Nut Island.

During the Calgon testing, a few conditions which appeared to hinder the effectiveness of the polymer-aided flocculation are reported. First, the influent wastewater temperature during March was about 50°F. By July the temperatures averaged nearly 70°F. Both the low temperatures in March and the seasonal variation were indicated as affecting the removal efficiencies occurring during the tests. A second condition noted was the uneven weirs in the settling tanks which created short circuiting regardless of flow rate.

Further investigation of chemical addition to aid sedimentation at Nut Island is recommended. Should this interim improvement be employed, it would produce greater quantities of sludge which might place additional load on sludge handling facilities.

(c) Use of tube settlers. Tube settlers have been successfully used elsewhere to improve settling efficiency. Since Nut Island tanks have chain-type sludge collectors rather than the traveling bridge type at Deer Island, the tanks could be filled with these units. To install tube settlers the full length of each tank would cost around one million dollars. However, it is expected that an effective arrangement of tube settlers at the effluent ends of the tanks only could provide significant improvement in solids removal performance. The associated costs would thus be less. Study of the feasibility of using tube settlers either alone or together with chemical treatment should be considered.

b. Other deficiencies and recommendations. In addition to the major concerns presented already, the following list of observed deficiencies and recommended programs has been developed as a result of our field examinations.

(1) The seven-day circular chart recorder on the influent flow meter should be converted to a one-day recorder to expand the readout or the unit replaced with a 30-day strip chart recorder.

(2) The use of equal volume-equal time automatic samplers should be discontinued and replaced with new flow proportioned samplers.

(3) Flow measurement and recording should be provided on bypass and overflow discharges.

(4) Ash from incinerated grit and screenings is reportedly discharged with the plant effluent into Quincy Bay. Consideration should be given to disposal to land or discharge of ash in the sludge outfall to deeper waters of President Roads in Boston Harbor.

(5) Raw sludge and scum pipes are reported to frequently plug with grease. Replacement with glass-lined pipes can be expected to greatly reduce plugging problems.

(6) Primary sensing devices need standby or replacement units together with means to calibrate and check their accuracy.

(7) The existing plant effluent is of poor quality for use as process water for auxilliary plant systems. A small water reclamation plant or a public water supply with positive backflow prevention should be provided.

(8) BOD analyses should be performed on the sludge discharged in the outfall in order to determine the overall effluent loadings upon the receiving waters from the Nut Island Plant.

(9) Because no BOD and coliform concentration analyses are performed presently upon the sludge discharge, the effectiveness of any sludge chlorination practices can not be substantiated. Chlorination of the sludge using existing equipment, along with sludge analyses for BOD and coliform should be performed to determine the justification of a sludge chlorination program at Nut Island.

(10) One of the engine-generator sets can operate only on gas and cannot operate on oil as the dual fuel engines can. A liquified petroleum gas-air installation could serve as a standby source of fuel and eliminate outage when digester gas supply is insufficient.

(11) The Nut Island facilities appear to contain many dangerous situations which are hazardous to the safety and health of employees and visitors. An independent safety inspection should be conducted and corrections made wherever the findings are significant.

(12) Operation and maintenance manuals should be provided and formal training programs maintained.

(13) A contingency plan is needed to assure treatment during strikes or disasters.

(14) We confirm the observations of others that most of the equipment and architectural features at Nut Island are in poor condition, suffering from deferred maintenance and twenty-five years of exposure to a very severe environment. Although MDC has begun a limited rehabilitation program, much more extensive upgrading of the faciltiies is essential in order to improve performance, increase reliability, and to extend the useful life of the Nut Island Plant.

(15) Because of the submerged inlet design on the sedimentation tanks, grease and scum separated by pre-aeration travels down the inlet channel and concentrates at the inlet of the furthest tank, heavily overloading its skimming equipment. Provision should be made for skimming the inlet channel to relieve this excessive load.

(16) Certain portions of the existing building and grounds must be modified to be accessible by and usable by the physically handicapped if a Clean Water Grant is accepted for other addtions or improvements to the facilities.

(17) Painting all process and chemical piping and equipment with color codes for safety and identification purposes should be done. Conformance to a standard system is suggested such as the one recommended in reference 2.15. Labeling equipment and valves is also recommended.

5. JOINT TASK FORCE OBSERVATIONS OF NUT ISLAND

As discussed in the section of the chapter on Deer Island, a joint task force of EPA and Massachusetts DWPC personnel investigated MDC manned facilities in the Boston area during the spring of 1976. This action was taken because of a prolonged shut-down at the Nut Island facility which resulted in the bypassing of the treatment units on January 30 and 31, 1976. The major effort of the task force was directed at reviewing Nut Island operations with the goal of making recommendations for improvements. This section of the chapter will review the findings, conclusions and recommendations of the draft report of the Joint Task Force, reference 2.4.

a. The pump stations serving Nut Island.

(1) Present status

In general these pump stations are old but well maintained. They are labor intensive and lack built-in reliability in terms of automation, duplication of units, and instrumentation.

The Squantum station does not have automatic start capability for its standby power. An alarm system does exist, although the station is manned only 8 hours per day. There is a "possibility of flooding at this location." Odor problems exist in the screen room despite ventilation system improvements.

The MDC Hingham pump station has two bypasses and receives flow from a City of Hingham pump station with capacity exceeding that at the MDC Hingham pump station. Only two of the three pumps in the station are automatically controlled at the present. The station bypasses to the Weymouth Back River, usually due to high flows or infiltration from the City of Hingham Sewer System.

The Quincy station is about 100 years old. Modernization of the facilities is ongoing.

The Braintree-Weymouth Station is slightly understaffed. Its pump discharge line is undersized for the rated capacity of the pumping units available. The single influent bar rack and grinder are difficult to work on and can not be bypassed. There is no metering or automatic control system for the pumps.

(2) Task Force recommendations

Alarm systems for Hingham and Squantum:

> "should ring at a manned station or MDC Police Station."

Also, system reliability should be improved, including provision of standby power, and equipment additions and replacement.

The MDC should continue modernization work at the Quincy Pump Station.

The vacant staffing positions at Braintree-Weymouth shall be filled and

> "consideration should be given to improving the discharge piping and influent bar screen arrangements."

b. Plant Headworks

(1) Present status

The mechanically cleaned bar screens were noted to be badly corroded and the bars are in need of replacement. The six grit channel inlet gates were in need of overhauling. The six grit collectors

> "had not served continuously for sometime."

Corrosion problems were evident in the grit and screening ejection equipment and controls. The Task Force considered the conditions warranted immediate attention due to the potential of severe injury to persons operating this equipment.

None of the alarm systems tested during the inspection functioned.

> "There is evidence that small fires have occured at the screenings area."

There was no evidence of emergency lighting in the incinerator tower. Problems existed with the scrubber system on the incinerator stack, which had allowed flue gases to bypass the scrubber.

There were nine effluent pumps which provided plant process water to various sytems. All but one were operational and two were planned to be replaced.

(2) Task Force recommendations

The recommendations were generally non-specific, but critical of the overall serious neglect of the headworks area. Routine and scheduled maintenance and records thereof should be maintained. The entire grit and screening ejection system should be overhauled.

c. Power and pumping

(1) Present status

There is no outside source of power at Nut Island. All power is generated by engines. Engine No. 1 was said to require a full overhaul. It ran hotter than the others and was usually used in winter only. The engine was in working condition, however, good quality digester gas was not available to run it. Engine No. 2 was overhauled recently and was operative. Engine No. 3 was being overhauled at the time of the Task Force visit.

The engines serving the pre-aeration blowers were in operating condition but leak oil badly and had not been inspected for five years.

The important jacket-water pumps serving the main engines were in working condition. However, the valves which isolate these pumps for repair needed work. It is necessary to shut down the system to work in either the pumps or the valves.

One of the four influent pumps was out of service during the Task Force visit. The remaining three were required to handle current high flows. Staffing was reported to be inadequate.

The following items were identified to result in possible power service interruptions:

(a) Loss of jacket water for any reason.

(b) Fewer than two of the full-size engines and generators operative.

(c) Lack of fuel oil or adquate digester gas.

(d) Problems with transformers or with electric distribution system.

(2) Task Force recommendations

The draft report stated the following:

> "A sound preventive maintenance program must be established. Adequate staffing must be provided to do the work on a routine basis. Equipment which has not received attention (raw sewage pumps, compressors, blowers, etc.) should be examined and the necessary work performed. A full inventory of the part on hand should be made and the necessary spare parts

> ordered. Standby power should be made available when the jacket and effluent water pumping systems are worked on. The necessary valves should be installed or replaced so that it is not necessary to shut down the whole system to work on one pump. This work should be done in warm weather, or adequate heat provided some other means in order to maintain the temperature in the anaerobic digesters. The elctrical system, which provides power to the engine auxiliary equipment should be examined for backups. The 30 kw generator will power one fuel oil and one jacket water pump, but unless there is dual feed to the substations (auxiliary pumping and raw sewage pumping) there is always the specter of service interruption through something happening to the cables themselves."

d. Primary sedimentation tanks

(1) Present status

In the preaeration area, there was built-up grit in the tanks and several of the diffusers required repairs. The poor condition resulted from lack of inspection for five years and lack of manpower, and funds for parts.

The six primary sedimentation tanks were being overhauled. All new iron work was being put in. Eventually all new chains and flights will be installed. Work and maintenance was based upon necessity, not schedule.

A second major problem identified was settling and cracking of the concrete structures themselves. This was studied in 1971 by The Thompson and Lichtner Co., Inc. They discovered tank settlement of up to 24 inches and some 12 inches differential settlement. The tanks were reported to be structurally sound but that reconditioning surfaces and repairs of cracks in floors and walls must be done.

A problem associated with the tank settlement was that the scum collectors were ineffective and the scum collected in the tanks. Likewise the structural distortions effected the sludge collection system.

The grease incinerator installed for disposal of scum and grease from tanks No. 5 and No. 6 had not been operative for three years.

The scum and sludge pumps in the three pump houses required overhaul or replacement. The plant staff had determined that overhaul was the better approach in this case. However, they were limited in parts and maintenance personnel. There was continual maintenance effort just to keep the sludge pumps running.

(2) Task Force recommendations

Their draft report stated the following:

> "It is recommended that the installation of new chains and flights be expedited and that necessary repairs to the concrete be made. All the primary sludge pumps need to be completely overhauled and rebuilt. The three new Wemco scum pumps should be installed. With these recommendations the primary sedimentation will be completely rebuilt."

e. Anaerobic digesters

(1) Present status

The digesters had not been drained and cleaned during the last eight years. A routine cleaning was critical since the plant pumps grease and scum to the digesters. Prior to the January shutdown, records indicated satisfactory digester performance.

Nearly all the pumps in the digestion system required attention. The heat exchangers and sludge discharge pumps needed to be rebuilt. The entire waste gas system needed to be overhauled.

When power was lost at Nut Island in January 1976, the digesters could not be heated, fed, or mixed. Even with emergency power, there was no heat to supply the digesters. The three units in service turned sour, and became inactive and stopped producing gas. As a result, the plant personnel pumped the raw sludge to No. 3 digester, which was being drained and out of service. They then discharged raw sludge to sea on out-going tides from this tank. This resulted in clogging of the discharge outfall line and overloading of the sludge pumps, requiring maintenance. Solids build-up in the outfall is usually hanlded by an annual cleaning using a "go-devil." When it became necessary to clear the line then, the "go-devil" required repair since it had not been properly cared for in two year. The cleaning operation took 24 times longer in this case than normal, due to the inefficiency of the pumps.

During the Task Force visit, the operational problems still existed in the digester and sludge discharge systems. The Task Force noted that the equipment that runs the system was not being maintained properly. The systems also had limited back-up and some had to operate constantly.

(2) Task Force recommendations

The draft report summarized the situation as follows:

> "The main recommendation in the digester system is the initiation of continuous routine and preventative maintenance programs. First, the heat exchangers and

> sludge discharge pumps should rebuilt. Then, the maintenance staff should completely go through all the pumps in the system and overhaul them. Finally, one man should be in charge of maintaining all the equipment in this area."

f. Chlorination

The Task Force reported that the chlorination system at Nut Island was "old-fashioned." Materials were apparently on hand to make improvements, however.

The layout of the system left much to be desired in terms of safety. Chlorine lines and rooms were not isolated. The ventilation system "does not inspire confidence." Danger of a chlorine leak in the lines existed. There was evidence of corrosion in both the chlorination room and the chlorine storage area.

The automatic system of chlroine dosage adjustment had been removed from service due to repeated failure. The chlorine dosage was controlled manually by operators who performed the orthotolidine "snap" test every two hours and adjusted the feed rate to maintain a "snap" residual of 0.7 ppm. The standard orthotolidine test is not approved for permit monitoring purposes and is an undesirable method for dosage control. The "snap" test is even less reliable than the standard test. Also, the chlorinators were not flow proportional and "the potential for inadequate control of chlorination is high."

Facilities avaiable at Nut Island to provide chlorination of the sludge discharge were disconnected at the time of the Task Force study.

The Task Force recommended implementation of already planned imporvements to the chlorination system. They further recommended repairs of the treatment units be done to eliminate any bypassing of the units. Better treatment of the wastewater before chlorination was considered needed to improve disinfection effectiveness and to reduce coliform counts.

g. Outfalls

The Task Force reported that the only mechanical problem existing was that the short, emergency outfall gate was stuck open during the inspection period. There was no reason for the condition to continue; however, no definite plans existed to repair it.

The major problem cited was tha bypasses are not recorded. Overflows may be occurring at the overflow spillway more often than the commonly assumed once or twice per year. Unfortunately, there was no flow measurement device at this location.

The Task Force recommended that bypass flow measurement equipment be installed at Nut Island.

h. General

The Task Force reported the need for expedited roof, brick and window repair at the Administration building. Also, it recommended replacement of the existing boilers.

The stockroom provided poor physical control of materials. A plant-wide, thorough inventory was recommended. The inventory control system should then be kept up daily.

i. Staffing and training

The following chart summarizes the staffing situation at the Nut Island Treatment Plant as compared with recommended EPA guidelines. This chart was developed by the Joint Task Force.

STAFFING	MNGMT	OPER	LAB	MAINT	OTHER	OFF/CLER	TOTAL
BUDGETED	2	26	5	33	3	2	71
RECOMMENDED* (Minimum)	2	35	3	28	3	3	74
ACTUAL	1	24	4	22	3	2	56
ACT-RECOM.	(1)	(11)	1	(6)		(1)	18
AVG. WAGE	$15,842	$11,141	$11,774	$8,795	$17,351	$8,846	$10,966

*Numbers were developed from a preliminary analysis based on extrapolated U.S. E.P.A. staffing guidelines. The numbers represent minimum needs for a well maintained and operated facility staffed with quality personnel. Variations between actual and recommended minimum numbers should be considered as potential problem areas that need examination by professional staffing experts.

The Task Force reported that 52% of the operators and management were certified and 67% had received occupational training. The following list provides a breakdown of operator certification at Nut Island by grade:

Grade VII	1 employee
Grade VI	0 employees
Grade V	2 employees
Grade IV	4 employees
Grade III	0 employees
Grade II	4 employees
Grade I	2 employees
	13 operators

j. Laboratory

The Task Force report identified and detailed certain aspects of the Nut Island laboratory, including staff, sample collection procedures, parameter tests and schedules, and laboratory techniques.

By NPDES permit, the plant is to test prescribed samples according to procedures detailed in the Federal Register Vol 38, No. 199 dated

October 17, 1973. The Task Force study noted that present laboratory methodology differed from those required in the tests for nitrate and nitrite nitrogen, and total and orthophosphate phosphorus. The methods of gas analyses used and the use of the orthotolidine method to determine chlorine residual are not recommended.

The study noted that no quality control was being practical at the Nut Island laboratory.

> "The precision and accuracy of the analyst and measurement systems in use at the laboratory have never been obtained. Tere is no plan to assure quality of methodology or validation of analytical results."

The study also listed equipment limitations existing and recommended actions to be taken.

The general comments and recommendations of the Task Force with regard to the laboratory were as follows:

> (1) "Collection of samples by laboratory technicians utilizes a significant amount of time. This time could be more effectively used in formal training or even by on-the-job training in laboratory testing and thereby ease the workload on the laboratory director and his only other assistant. Shift operators with some training could very effectively perform sample collections."
>
> (2) "The vacant chemist position should be filled. There is every reason to believe that the laboratory director should be relased from bench testing so that he can more properly supervise and develop important programs, such as, quality control and upgrade his analytical methodology."

> (3) "Equipment limitations should be removed and appropriate analytical procedures instituted to replace those non-quantitative HACH and OT chlorine methods. Such data collected for NPDES purposes would not be acceptable."
>
> (4) "An intra-laboratory quality control program should be initiated as soon as possible. This should include the development of statements of precision in the major parameters for the analyst and measurement system. A check sample performance evaluation survey should be conducted at least quarterly under the supervision of State authorities with EPA assistance."

6. IMPROVING PRIMARY TREATMENT AT NUT ISLAND - EMMA PLAN

The EPA approved plan for improving primary treatment at Nut Island will be reviewed herein, references 2.17, 2.18.

The EMMA Recommended Plan contains provisions to upgrade primary treatment facilities at Nut Island as priority item No. 5, at a capital cost of $50.5 million with a scheduled completion date of June 1984.

The Recommended Plan involves reducing the service area of Nut Island from 101 square miles to 91 by the year 2000. However, even with this reduction, the flows to the plant were estimated to increase above the present values. Table 2-14 presents some of the basic design criteria used in the EMMA Study in planning the Nut Island expansion.

As in the case of the Deer Island plan, the study bases its surface leading rates and detention times upon the operation of all tanks and chambers. As was noted in an earlier section, the recent operation at Nut Island has been able to average no better than 3.3 tanks in service out of the present total of six.

Table 2-14

BASIC DESIGN CRITERIA

NUT ISLAND PRIMARY EXPANSION

(Reference 2.14)

	Present	2000 Design	2050
FLOW (mgd)			
Average day	127	130	150
Peak day	211	224	251
Peak rate	310	310	310
BOD_5 (lb/day)			
Average	149,000	201,000	221,000
Peak	363,000	490,000	538,000
SUSP. SOLIDS (lb/day)			
Average	222,000	281,000	
Peak	439,000	556,000	
NEW AERATED GRIT CHAMBERS			
No. of Units	-	4	
Surface loading rate (gpd/ft^2)			
Average day	-	20,000	
Peak day	-	34,400	
Detention time (min.)			
Peak	-	3.4	
NEW PRIMARY SED. TANKS			
No. of Units	6	9	9
Surface loading rate (gpd/ft^2)			
Average day	1,788	1,220	1,410
Peak day	2,970	2,100	2,350
Peak	4,364	2,910	2,910
EFFLUENT PUMPING STATION			
Average Flow (mgd)	127	130	
Peak Flow (mgd)	310	310	
NEW OUTFALL			
Diameter, (ft)	-	5	
Length, (ft)	-	5,100	

The design flow values were developed with consideration of industrial, commercial and residential wastewater flows, plus infiltartion allowances. The peak flow of 310 mgd is based upon the trunk sewers full-flow capacity which may not be adequate to avoid overflows, some of which occur at this time.

The design BOD and solids loadings were developed from analyses of existing plant data covering the period of January 1970 to December 1972, inclusive.

EMMA recommends altering the preliminary treatment at the headworks in order to use existing structures while reducing overflows when flow exceeds 210 mgd. Basically, the two bar screens would be removed and new bar screens installed ahead of each of the existing six grit chambers. Also, all nine comminutors would be removed and four new aerated grit chambers would be constructed downstream of the influent pumps. The present incinerator and appurtenant equipment would remain. The existing grit chamber chains flights and collectors would be replaced.

Although, headlosses upstream of the influent pumps would be reduced, downstream headlosses might be increased due to added aerated grit chambers. Therefore, the EMMA report calls for further study during design before new pumping units are recommended.

The EMMA Study recommends that the existing six primary sedimentation tanks be supplemented by three new tanks, also equipped with covers. This was based upon reducing the surface loading rates to satisfactory levels for primary settling which is to be followed by secondary treatment. If, however, secondary treatment is not required, then two tanks would be added to reduce surface loading rates still further, for primary treatment alone. The total number of tanks in the expanded primary plant would then be eleven. Table 2-14 shows the proposed surface loading rates under the plan of nine tanks followed by secondary treatment. In the expanded (eleven tank) primary plant plan, the peak surface loading rate would be reduced to 2,380 gpd/ft^2 and the average surface loading rate would be reduced to below 1000 gpd/ft^2, when all tanks are in service.

By adding three settling tanks at Nut Island, the detention time during peak flow with all nine tanks in service would be about 49 minutes. From Figure 2-6, we can expect the following removals to occur during such a detention period:

Settleable solids	85-90%
Suspended solids	42-48%
BOD	15-25%.

During average flow conditions, the detention period, assuming all tanks in service, would exceed two hours. This excceds the data plot available in Figure 2-6. However, it can be expected that considerable additional solids removals would occur and somewhat better BOD removals as well.

The present outfall system was recommended to be altered as follows: The emergency overflow weir would be abandoned. The short (1412 feet) outfall would be extended by 5000 feet to provide a third long outfall for full-time use.

Preliminary studies indicated that an effluent pumping station might be needed in the EMMA plan. This was based upon high tide and peak flow conditions. The necessary amount of operation of such a station was estimated at one percent of the time. The pumping station would include five 78 mgd pumps, with one as a standby unit.

The existing chlorinators and appurtenances would be moved from the Administrative Building to a new building under the EMMA plan. A new chlorine feed system would be provided to permit use of tank truck bulk supply of chlorine. Also, the EMMA recommendation includes increasing the capacity of the existing chlorination system to provide standby facilities and increased pre-chlorination capability. With three long outfalls in service, the expanded plant would provide 15 minutes of chlorine contact time at peak flow.

The EMMA recommended plan with regard to sludge management was presented in the Deer Island portion of this chapter. For Nut Island, primary sludge would be thickened and pumped to Deer Island for further processing. Scum would be collected at Nut Island and incinerated in a new facility under the EMMA plan.

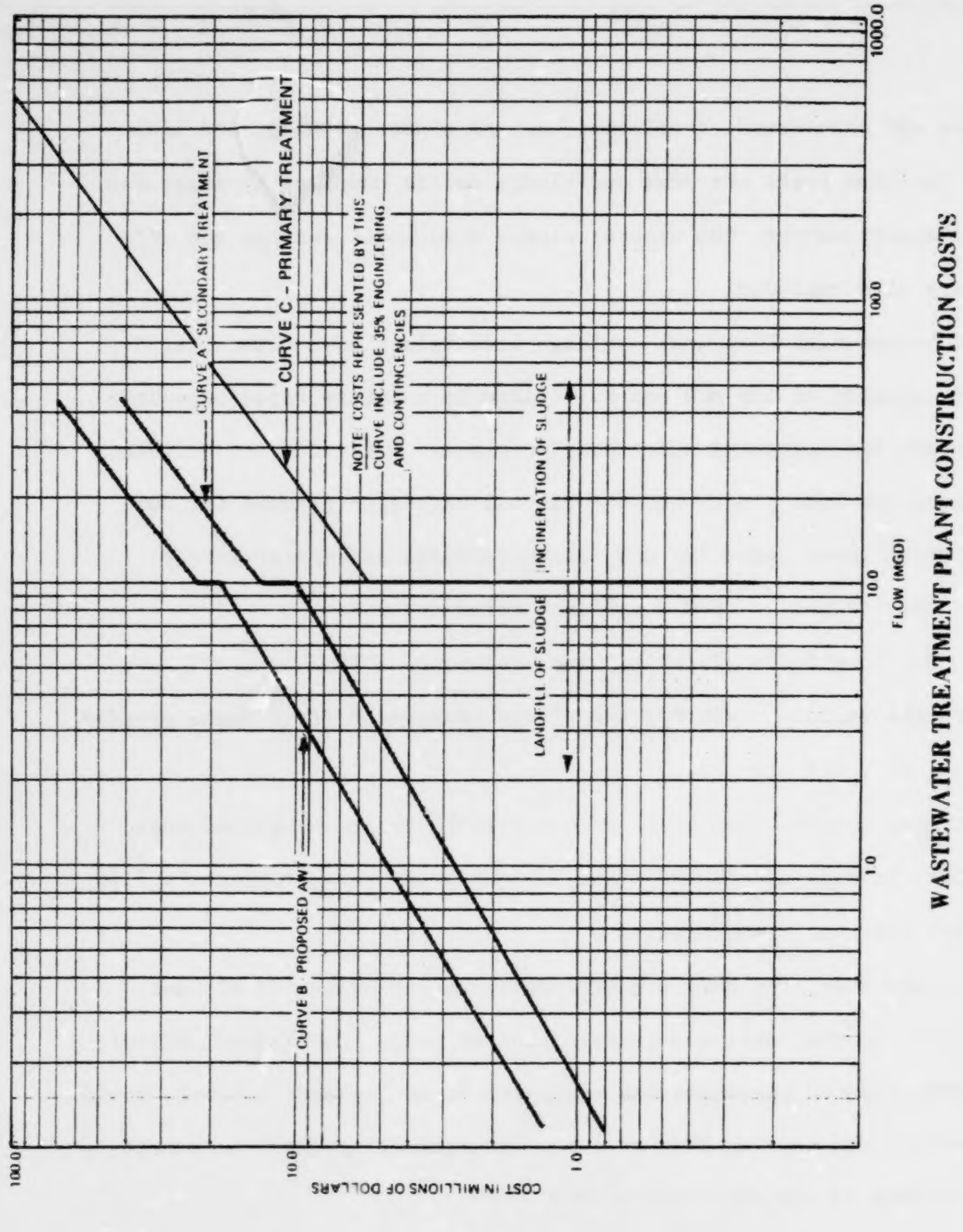
The projected capital cost of revamping and expanding the existing primary plant as discussed above is $50.5 million. This is based upon an ENR index of 2200, and includes a 35 percent allowance for engineering and contingencies. The costs exclude sludge disposal facilities. Also, an additional $4.1 million would reportedly be required to cover the three new tanks. If the expansion of the plant was not followed by secondary treatment facilities construction, two more primary tanks would be constructed and are not included in the $50.5 million figure. The estimated total annual operation and maintenance costs of the expanded primary plant was given as about $2 million, excluding sludge management.

C. COSTS

The previous sections of this chapter have discussed the wastewater treatment facilities at Deer Island and at Nut Island. The present facilities and their treatment efficiencies were examined. Present deficiencies and recommendations for correction were presented. Costs for these needed improvements were not a part of the scope of the Joint Task Force review. The EMMA Recommended Plan reviewed in Chapter 3, includes facilities for upgrading and expansion of the existing facilities. It is anticipated that the plant upgrading and expansion costs presented in the EMMA Recommended Plan would provide for most of the major needs of these plants. However, we feel that the magnitude of the planned upgrading and expansion costs in the EMMA Study should be compared with the cost of constructing new equivalent primary plants.

Estimated capital costs for primary treatment plant construction used in this section are based upon prices of comparable work on which we have knowledge, as well as from project data in professional journals and construction magazines. Costs were adjusted to an ENR of 2200 and include 35 percent for Step 1 and 2 engineering, and contingencies.

Figure 2-8 from Volume 2 of the EMMA Report included Curves A and B for secondary and advanced wastewater treatment plant construction costs, reference 2.21. We have added curve C on the Figure to show primary treatment plant construction costs separately. Curve A represents costs for all basic plant facilities such as influent headworks, raw waste screening, influent pumping, aerated grit removal, sedimentation tanks and equipment, disinfection facilities,



WASTEWATER TREATMENT PLANT CONSTRUCTION COSTS

Source: Curves A and B from EMMA REPORT, Volume 2 by Metcalf and Eddy

NSF Boston Case Study, Phase II Evaluation

WASTEWATER TREATMENT PLANT CONSTRUCTION COSTS

Kennedy Engineers, Inc.
1977

Figure **2·8**

administrative and maintenance facilities, access roads, parking, and landscaping. It includes costs for scum and sludge solids handling by anaerobic digestion and appurtenances, but without sludge disposal. Outfall and effluent pumping are also excluded.

The EMMA Recommended Plan would enlarge Deer Island to a future rated average daily capacity of 400 MGD and Nut Island to a future rated capacity of 130 MGD, under the upgrading and expansion phase. Excluding the effluent pumping stations for both plants and the outfall extension planned for Nut Island, the EMMA planned upgrading and expansion costs are approximately:

Deer Island	$30.2 million, reference 2.3.
Nut Island	$41.3 million, reference 2.18.

These figures exclude costs for the sludge management first phase program (incineration), priority item No. 1.

The estimated construction costs of new primary treatment plants rated at 400 MGD (Deer Island) and 130 MGD (Nut Island) would be approximately $100 million and $40 million, respectively.

Thus by comparison, the EMMA planned upgrading and expansion at Deer Island would cost approximately 40 percent that of a new "equivalent" primary plant. The EMMA planned upgrading and expansion at Nut Island, however, would cost approximately the same as that of a new "equivalent" primary treatment plant, * (exclusive of any extra conveyance costs.)

Because the cost of constructing a new primary treatment facility is estimated to be virtually the same as improving and expanding the existing Nut Island treatment plant, and this work on the existing plant presents many

---

* (The 1978 draft EIS reached the same conclusion.)

additional problems, we believe that careful consideration should be given to building a new plant at another site. Some of the primary concerns we have identified are as follows:

1. Nut Island site is restricted in size. Even the planned primary treatment additions require some filling of Quincy Bay. Addition of secondary treatment would require extensive filling. There are strong environmental objections to bay fill and plant expansion at the present location. In fact, there are objections, based on odor and aesthetics to maintaining any treatment at Nut Island.

2. Foundation conditions are poor. Existing structures have experienced severe settlement.

3. Existing buildings, utilities and equipment have deteriorated severely. Continued use will result in much higher maintenance costs than a new plant. There will need to be expended unestimated amounts to meet present safety requirements and requirements for access of handicapped.

4. The severe settlement of the sedimentation tanks has caused distress to the structures. The differential settlement increases equipment wear and prevents proper operation of skimmers because they are not parallel with the water surface. While it is reported that the effluent overflow weirs can be adjusted to be level, even with some 12 inches of differential settlement, it may turn out to be difficult or impossible. Even if accomplished, skimming problems will remain and possibly some loss of tank volume. It is probable that additional settlement of these tanks also would be induced by future construction in the plant area.

5. Because major modifications of the plant would be necessary, the Nut Island treatment plant would be out of service for an extended period, requiring prolonged raw sewage discharge.

As discussed earlier, we have estimated that the cost of covering the existing tanks at Deer Island would be about $5 million. It is an action that could be taken to aid in keeping more tanks in service at this plant. If the expansion of Deer Island was to include costs for covering all new sedimentation tanks and providing a new pumping station, the total costs of the plant upgrading and expansion might increase by about $50 million.

D. OPERATION AND MAINTENANCE PRACTICES

This section reviews present operation and maintenance practices and presents suggestions for improvement for MDC facilities at Deer Island and Nut Island.

The operation and maintenance budgets in effect since July 1, 1973 reflect directives to prepare budgets based upon minimal "bottom line" figures and which imposed a hiring freeze, according to the MDC.

1. EXISTING TRAINING PROGRAMS, MANUALS AND CERTIFICATION PROGRAMS

At both Deer Island and Nut Island the plant staffs have prepared operation and maintenance manuals for process operations. There is a separate manual for each unit process at each plant. There are, however, no formal training programs for operators at either plant.

Of the various pumping stations and headworks visited, only at the Columbus Park Headworks was it noted that a "operations manual" exists. It was prepared by the headworks operating staff. No formal training program exists at any of these facilities.

In reviewing the list of Environmental Training Programs in New England (Reference 2.22) published by the EPA Region I, the following overview of training programs was derived. Ten institutions of higher education in Massachusetts provide programs toward Bachelor of Science degrees or higher in environmental studies. Eight other institutions in the State provide Associate Degrees of Science in Environmental Studies. Also, there are three State or EPA sponsored wastewater treatment plant operator training programs in Massachusetts at present. These training programs, however, are provided at institutions located outside the Greater Boston Area.

Reportedly, the EPA sponsors two correspondence courses on operation and maintenance of water collection and water management systems. The EPA has reportedly provided an instructor technology course and a trouble-shooting course related to operation and maintenance. It is apparently up to the State as to who is to take these courses.

The present State Rules and Regulations for Certification of Operators of Wastewater Treatment Facilities resulted from the Legislative Acts of 1970 and 1971 of the Commonwealth of Massachusetts (reference 2.23). The Rules define a Wastewater Treatment Plant Operator as any person performing "important operating functions" of a wastewater treatment facility. The term Wastewater Treatment Plant refers to a "facility used for treating, neutralizing or stabilizing wastewater from homes, public buildings, commercial or industrial establishment or any combination thereof." The Rules and Regulations categorized each treatment facility as Class I, II, III, IV, V, VI, or VII (the highest) based upon the complexity of the facility and the equivalent population served. The Treatment Plant Operator-in-Charge is the person who is in responsible charge of the operation during all working shifts of a treatment facility. He is to have a grade equal to that of the plant (I through VII). The chief operator position cannot be filled by any employee who does not spend his working hours at the treatment facility. The State Regulations require only that one certified operator be provided for each treatment facility, but his grade must equal or exceed that of the facility. There is no requirement that a fully qualified operator be on duty during all shifts of plant operation. Prior to the Rules and Regulations, there existed a voluntary certification program which was administered by the New England Water Pollution Control Association.

The Nut Island and Deer Island treatment plants are both Grade VII. The Deer Island headworks and MDC pumping stations are classified Grade I. Various other facilities of each grade exist within the study area also. The Cottage Farm Stormwater Detention and Chlorination Facility discussed in Chapter 5 is classified Grade IV, for example.

Since EPA does not include in NPDES permits in Massachusetts, requirements that plants be operated at all times by certified operators, for existing facilities not grant funded, certification requirements are controlled by State regulations. For PL 92-500 grant funded projects, the regulations provide that plants be operated by properly trained and qualified personnel, in accordance with regulations issued by the Administrator from time to time. To date, no definition has been made as to "properly trained and qualified." Indirectly, some control of operation staffing may be exercised by EPA when they accept the Operation Manual on a grant project. The manual is required to establish staffing and staff qualifications for facility operation and maintenance. A grant condition is that the facility be operated in accordance with the manual. This could be construed as requiring the staffing set forth.

In the previous sections of this chapter under the EPA Joint Task Force review of Nut Island and of Deer Island, a listing of plant operator grades was presented. Of the staff at Deer Island and its headworks, 43 percent of the operations and management personnel are certified Grade I or greater. There is one Grade VII operator, as required, out of about 200 employees. The EPA Task Force also reported that 60 percent of the Deer Island staff had received some sort of occupational training (Reference 2.4). At Nut Island, 52 percent of the operations and management personnel are certified Grade I or greater. Again, only the one Grade VII operator is provided, as required. The EPA Task Force reported that 67 percent of the Nut Island staff have received occupational training (Reference 2.4).

2. RECOMMENDED IMPROVEMENTS

The Federal Guidelines - Operation and Maintenance of Wastewater Treatment Facilities published by the EPA (Reference 2.24) are intended to assist grantees of Clean Water Grants in meeting PL 92-500 requirements. As a condition of these awards, the grantee must make adequate provisions for efficient operation and maintenance of grant funded facilities.

The Act calls for a cost effectiveness analysis of alternatives for a waste treatment facility during the Facilities Planning Step for which a grant is requested. One element of this analysis calls for:

> "An evaluation of improved effluent quality attainable by upgrading the operation and maintenance and efficiency of existing facilities as an alternative or supplement to construction of new facilities."

If grant assistance is for a project involving Step 3 Construction, it shall not be awarded unless it is determined that:

> "..satisfactory provision has been made by the applicant for assuring proper and efficient operation and maintenance of the treatment works, in accordance with 35.935-12, and that the State will have an effective operation and maintenance monitoring program to assure that treatment works assisted under this subpart comply with applicable permit and grant conditions."

Section 35.935-12 states:

> "(a) The grantee must make adequate provisions satisfactory to the Regional Administrator for assuring economic, effective, and efficient operation and maintenance of such works in accordance with a plan of operation approved by the State water pollution control agency or, as appropriate, the interstate agency, after construction thereof.
>
> "(b) As a minimum, such plan shall include provision for: (1) An operation and maintenance manual for each facility, (2) an emergency operating and response program, (3) properly trained management, operation and maintenance personnel, (4) adequate budget for operation and maintenance, (5) operational reports, and (6) provisions for laboratory testing adequate to determine influent and effluent characteristics and removal efficiencies.
>
> "(c) The Regional Administrator shall not pay (1) more than 50 percent of the Federal share of any Step 3 project unless the grantee has furnished a draft of the operation and maintenance manual for review, or adequate evidence of timely development of such a draft, or (2) more than 90 percent of the Federal share unless the grantee has furnished a satisfactory final operation and maintenance manual."

The Federal Guidelines were developed for use in either development of new facilities or in upgrading the operation and maintenance procedures and programs of existing facilities.

The Discharge Permit issued August 12, 1976 for the MDC states the following requirement under GENERAL CONDITIONS, paragraph E:

> "All waste collecton, control, treatment, and disposal facilities shall be operated in a manner consistent with the Division's "Rules and Regulations for Operation and Maintenance of Sewerage Systems and Waste Treatment Facilities," as most recently amended, and any applicable Federal Regulations and Guidelines, which regulations are hereby incorporated into and made a part of this permit. The permittee shall at all times maintain in good working order and operate as efficiently as possible any facilities or system of control installed or utilized to achieve compliance with the terms and conditions of this permit."

The term Divison refers to the Massachusetts Division of Water Pollution Control.

3. RECOMMENDATIONS

a. Under Massachusetts State Law, only one person needs to be a certified operator at each facility. There are over two hundred employees assigned to Deer Island but one-third of them work at remote sites. There are sixty-five employees assigned to Nut Island. One operator with certification equal to facility grade should be on duty at all times. Certified operators should also be in charge of each satellite facility. All operation personnel should be encouraged to obtain certification through pay incentive.

b. There is a need for continuing training programs for operation and maintenance personnel. This should include safety training of all plant, pump station and headworks personnel.

c. Operations and maintenance manuals should be prepared for and be on hand at each of the remote headworks and pumping stations, as well as at each treatment facility.

d. Contingency plans should be developed at each facility to assure continued operation during strikes and natural disaster conditions.

E. SUMMARY OF CHAPTER 2

1. The Deer Island Plant is reported to have discharged to President Roads, an average of daily flows of 329 mgd during fiscal year 1975-1976. The average daily flows ranged from approximately 200 to 500 MGD. The peak hourly flow rate was 520 mgd. During that period, the daily effluent discharge contained the following mass emissions in Boston Harbor:

260,000 pounds of BOD,
210,000 pounds of Suspended Solids,
43,000 pounds of Grease,
8.6×10^{12} Millipore Filter (MF) Coliform, and
1100 pounds of chlorine.

Considerable additional loading would have been discharged by the plant if the headworks had not diverted flows to overflows, due to restricted pumping capacity at the treatment plant.

2. The Deer Island Plant also discharged sludge and scum with the effluent, but only during ebb tides. During fiscal year 1975-1976, sludge and scum contained between 65,000 and 100,000 pounds per day of total solids, of which about forty-eight percent were volatile solids. The BOD and bacterial content of the discharged sludge are not known. Assuming a BOD concentration of 25,000 mg/1, the sludge would amount to an additional 67,000 pounds per day BOD loading to President Roads. Elimination of the sludge solids discharge is estimated to reduce the total emissions from Deer Island by over 20 percent.

3. Present pumping facilities at Deer Island cannot handle the flows that need to be conveyed out of the sewered member communities in the Deer Island service area, particularly during high tide and during periods of

wet weather. As a result, it is frequently necessary to limit the influence at the headworks causing backup and overflows of untreated wastewater throughout the sewerage system.

4. A combination of moisture, salt air, and sewage gases create a very severe environment at Deer Island. These factors, together with minimal maintenance budget and staffing have caused corrosion and deterioration to affect the reliability of the treatment facilities at this eight-year old plant.

5. The practice of disposing of snow to the combined sewers encourages ice formation on the surface of the Deer Island sedimentation tanks. This results in structural damage to the sludge and scum removal mechanisms and causes tanks to be shut down for repairs. Only six of the eight tanks were operable over half the time during FY 1975-1976, while only four tanks were usable during extreme conditions.

6. The Deer Island plant, in spite of problems and overloading appears to be performing remarkably well at the flow rates accepted. Considering present high surface loading rates, significant efficiency reduction can be expected when the influent pumping capacity is restored to 900 mgd, almost three times the plant design capacity of 343 mgd.

7. The NPDES permit for Deer Island, together with the ECSL, specify liberal limits to which the existing plant effluent is required to conform until October 1, 1984. The monthly average allowable daily emissions, exclusive of sludge, are as follows:

Parameter	Emission	Units
Average daily flow	403	MGD
Peak flow	Unlimited	-
BOD	474,000	Pounds per day*
Suspended solids	306,000	Pounds per day**
Grease	No numerical limit	--
Coliform bacteria	No numerical limit	--

*or shall not exceed 74% of the influent load

**or shall not exceed 58% of the influent load

The average daily flow was 329 mgd in FY 1975-1976. BOD and suspended solids removals of 26% and 42% respectively are easy to attain even for a plant which was designed with high loading criteria and which has as few as one-half of its tanks out of service part of the time.

This is especially true because the weekly average of daily emissions are allowed to exceed the above amounts by three percent and the emissions on the maximum day in each month may exceed the above amounts by forty-three percent. An additional aid in meeting permit standards has been the diversion to overflow or by-pass of peak flows due to availability, at times, of only one-fourth of installed pumping capacity.

It should be noted that present flows and influent loadings are well below the amounts limited by the NPDES permit. The terms of the permit are such that when there is more influent loading, more effluent emissions are allowed. Thus a considerable amount of additional flow and/or strength of wastewater can be discharged, and still comply with NPDES permit effluent limitations.

The ECSL permit also requires attainment of secondary treatment level by July 1, 1985 with monthly averages of daily emissions allowed by the NPDES permit as follows:

Parameter	Emission	Units
Average daily flow	Not given, assume 403	MGD
Peak flow	No limit	-
BOD	101,000	Pounds per day*
Suspended solids	101,000	Pounds per day*
Fecal coliform bacteria	200	per 100 ml
Total coliform bacteria	1,000	per 100 ml

*or shall not exceed 15 percent of the influent loadings, which is the same as 85 percent removal.

The issue here is that for the nine-month period during which the expanded Deer Island primary treatment plant is required to be operational (before secondary treatment facilities are operational) there are no effluent limitations or performance requirements in effect.*

From a technical standpoint it is necessary that performance levels of the expanded primary facilities be established early in the planning process in order to define the influent loadings to the secondary process units.

Overall treatment objectives can, in general, be satisfied by varying amounts of pollutant removal achieved in either the primary or in the secondary treatment units. It is important to optimize and establish performance for the primary treatment facilities, which will also be the secondary treatment unit influent. This is particularly significant where design of the secondary facilities may be performed by a different designer than those designing the primary treatment expansion. Provision must also be made in the primary facilities to accommodate waste sludge and other appurtenant streams from the secondary facilities.

---

* (EPA advises that limits will be placed when it determines what limits are feasible.)

8. The Deer Island Plant can be restored and upgraded and the capacity increased to accommodate an average daily flow of 400 MGD as outlined in the EMMA Study, for about one-half of the cost of an equivalent new plant. This would include a new additional item of construction for covering the sedimentation tanks. Top priority should be given to restoring full pumping capacity which would immediately require peak flow treatment capacity of over one billion gallons per day, including flows from the Winthrop Terminal facilities. Consideration should be given to building a new pumping station to handle flows from the Boston Main Drainage Tunnel and converting the existing pump station to pump only from the North Metro Relief Tunnel. This would require enlarging Ward Street and Columbus Park headworks and further expanding plant primary treatment capacity.

Other major items needed are: additional preaeration channels, additional chlorine contact chambers, and additional capacity in the outfall and diffuser systems.

Other categories of work needed at Deer Island include improvements to the chlorine diffusion, mixing and control system, flow measuring systems, instrumentation, reclaimed water system, screenings equipment, headgates, sampling systems, and other miscellaneous plant improvements to aid operation, improve safety, and to increase reliability.

Management improvements should include the full use of pumping capacity including those at the Winthrop Facilities, daily performance sampling and monitoring, development of a viable contingency plan to avoid plant shutdowns, and formal on-going programs for training and certification of the staff.

9. Because of highly variable influent loadings including rapidly changing chloride concentrations, pilot plant treatability studies prior to selection of the secondary treatment process at Deer Island are indicated.

10. A major significant beneficial impact on the harbor would be the elimination of the present sludge discharge. This is the EMMA Recommended Plan Priority Item No. 1, Primary Sludge Management Facilities.

11. The Nut Island Plant handled an average daily flow of 123 MGD during Fiscal Year 1975-1976. The sewage effluent contained the following estimated average daily emissions to Nantasket Roads:

124,000 pounds of BOD,
116,000 pounds of suspended solids,
23,000 pounds of grease,
2.8×10^{12} millipore filter (MF) coliforms, and
1,300 pounds of chlorine

The amount of by-passes and overflows is not known.

12. Sludge is discharged from Nut Island to President Roads together with a portion of the sewage effluent. The average daily sludge discharge

during FY 1975-1976 was 217,000 gallons per day. The sludge discharged contained an estimated 40,000 pounds per day of total solids of which 58.7 percent were reported as volatile solids. The concentration of BOD and bacteria in the sludge is not known.

13. The Nut Island Plant is overloaded. The average flow to it exceeds the rated capacity of the plant. During FY 1975-1976, as few as three of the six sedimentation tanks were in service over half the time. The plant is in very poor condition due to its age and severe deterioration.

The MDC construction staging program shows the Nut Island primary treatment improvements (Priority Item No. 5) to be completed in the summer of 1984, at which time the present major treatment units of the plant will be thirty-four years old. The Nut Island facilities are now critically in need of repair, restoration, upgrading, and expansion, for which there is insufficient space on the site.

14. The EMMA Recommended Plan, Priority Item Number 5, includes an amount of $50.5 million for primary treatment improvements to the Nut Island Plant. We believe that the costs involved are as much as would be required to construct an entirely new primary treatment plant at another location. It appears cost-effective to abandon the Nut Island Site and build a new plant at another site.

15. The NPDES permit for Nut Island, together with the ECSL, specifies very liberal effluent limits which the plant effluent is required to meet until October 1, 1984. The allowable monthly averages of daily emissions

are not to exceed the following:

Parameter	Emission	Units
Average daily flow	180	MGD
Peak flow	Unlimited	-
BOD	248,000	Pounds per day*
Suspended solids	210,000	Pounds per day**
Grease	No numerical limit	-
Coliform bacteria	No numerical limit	-

*or shall not exceed 78% of the influent load
**or shall not exceed 56% of the influent load

Weekly emissions are permitted to be nine percent greater, and the maximum daily emissions are permitted to be twenty-one percent greater.

The average daily flow for fiscal year 1975-1976 was 123 MGD and the rated design capacity is only 112 MGD. Even with the overloaded conditions, the required BOD and suspended solids removals of 22 percent and 44 percent as a monthly average can be achieved most of the time.

There are no effluent limitations stipulated for the expanded Nut Island primary treatment plant. The next date when effluent limits appear to become effective is July 1, 1985 and are for secondary treatment. At that date monthly average of daily discharge limits are based on a secondary treatment level and limited as follows:

Parameter	Emission	Unit
Average daily flow	Not given, assume 180	MGD
Peak flow	No limit	-
BOD	45,100	Pounds per day*
Suspended solids	45,100	Pounds per day*
Fecal coliform	200	per 100 ml
Total coliform	1,000	per 100 ml

*or shall not exceed 15 percent of the influent loadings

Weekly average emissions can be fifty percent greater and the maximum day may contain sixty percent more BOD and SS.

It can be observed that the permit process has not not been utilized as a method of establishing a level of performance of the proposed expanded primary treatment facilities.

REFERENCES

2.1 Metropolitan District Commission, Sewerage Division/Commonwealth of
Massachusetts, "Fifty-Sixth Annual Report Fiscal Year Ending June 30,
1975."
August 21, 1975

2.2 Metcalf & Eddy, Inc., Et al
"Wastewater Engineering and Management Plan for Boston Harbor-
Eastern Mass. Metropolitan Area EMMA Study."
Volume 9 - MDC Interceptors and Pumping Stations
October 1975

2.3 Metcalf & Eddy, Inc.
"Wastewater Engineering and Management Plan for Boston Harbor-
Eastern Mass. Metropolitan Area EMMA Study."
Volume 10 - Deer Island Wastewater Treatment Plant
October 1975

2.4 EPA Region 1
"Joint Task Force Report on Major Manual MDC Facilities
Located in the Greater Boston Area."
Draft Copy, May 1976

2.5 U.S. EPA/Mass. DWPC
"Metropolitan District Commission NPDES Discharge Permit"
Federal Permit No. MA 0102351
Issued August 12, 1976

2.6 Metropolitan District Commission - Sewerage Division
Monthly Data Sheets for Deer Island Treatment Plant
July 1, 1975 - June 30, 1976

2.7 Metcalf & Eddy, Inc.
Wastewater Engineering: Collection, Treatment, Disposal
McGraw-Hill, Inc.
1972

2.8 Fair, Geyer and Okun
Water and Wastewater Engineering, Vol. 2
Wiley and Sons, Inc.
1968

2.9 Hydroscience, Inc.
"Development of Water Quality Model of Boston Harbor."
July 1971

2.10 Metropolitan District Commission - Sewerage Division
"Fifty-seventh Annual Report Fiscal Year Ending June 30, 1976."
October 14, 1976

2.11 Metropolitan District Commission - Sewerage Division
"Fifty-third Annual Report Fiscal Year Ending June 30, 1972."
(undated)

2.12 Metropolitan District Commission - Sewerage Division
"Fifty-fourth Annual Report Fiscal Year Ending June 30, 1973."

2.13 Metropolitan District Commission - Sewerage Division
"Fifty-fifth Annual Report Fiscal Year Ending June 30, 1974."
January 21, 1975

2.14 TCE, Inc.
"Structural Evaluations and Ecological Observations in
Boston Harbor."
March 1973

2.15 New England Interstate Water Pollution Control Commission
"Guides for the Design of Wastewater Treatment Works."
June 1971

2.16 Roy F. Weston, Inc. for EPA
"Process Design Manual for Upgrading Existing Wastewater
Treatment Plants."
Program No. 17090 GNQ Contract No. 14-12-933
October 1971

2.17 Metcalf & Eddy/Corps of Engineers/MDC/et al
"Wastewater Engineering and Management Plan for Boston
Harbor - Eastern Massachusetts Metropolitan Area
EMMA Study." Main Report
March 11, 1976

2.18 Metcalf & Eddy, Inc.
"Wastewater Engineering and Management Plan for Boston
Harbor - Eastern Massachusetts Metropolitan Area
EMMA Study." Volume II - Nut Island Wastewater Treatment Plant
October 1975

2.19 Metropolitan District Commission - Sewerage Division
Monthly Data Sheets for Nut Island Treatment Plant
July 1, 1975 - June 30, 1976

2.20 Calgon Corporation for the Massachusetts DWPC
"Report on Primary Flocculation Demonstration
MDC Nut Island Plant."
August 17, 1971

2.21 Metcalf & Eddy, Inc.
"Wastewater Engineering and Management Plan for Boston
Harbor - Eastern Massachusetts Metropolitan Area
EEMA Study, Volume 2 - Engineering Criteria
October 1975

2.22 EPA Region 1
"Environmental Training Programs in New England."
October 1976

2.23 Massachusetts Board of Certification of Operators of Wastewater
Treatment Facilities
"Rules and Regulations for Certification of Operators of
Wastewater Treatment Facilities."
(Undated)

2.24 EPA Office of Water and Hazardous Materials
"Federal Guidelines - Operation and Maintenance of
Wastewater Treatment Facilities."
August 1974

CONTENTS

Chapter 3

ANALYSIS OF EMMA STUDY

Section	Title	Page
A.	PRELIMINARY ANALYSIS	3.2
	1. Administrative Procedures	3.2
	2. Study Area	3.5
	3. Wastewater Management Strategies	3.7
	4. Cost Levels	3.17
	5. Recommended Plan by Needs Category	3.19
B.	BASIC DESIGN CRITERIA	3.21
	1. Deer Island System	3.22
	2. Nut Island System	3.25
C.	CONSTRUCTION STAGING PROGRAM	3.30
D.	PRESENT WORTH ANALYSIS OF RECOMMENDED PLAN	3.32
	1. Basis of Analysis	3.32
	2. Present Worth Analysis Methodology	3.39
	3. Present Worth Analysis	3.40
E.	APPARENT REAL DOLLAR COSTS OF RECOMMENDED PLAN	3.45
F.	APPARENT UNMET NEEDS	3.51
	1. Inside expanded MSD Service Area	3.51
	2. Peripheral Area	3.56
G.	LOCAL RESULTS OF NEEDS SURVEYS	3.58
H.	SUMMARY OF CHAPTER 3	3.69
	REFERENCES	3.78

CONTENTS OF CHAPTER 3, Continued

			Page
FIGURE	3-1	Dry-Weather Flow Alternatives	3.12
	3-2	Recommended Plan for Dry-Weather Flow	3.13
	3-3	Wet Weather Flow Alternatives	3.18
	3-4	Construction Staging Costs vs. Time	3.31
TABLE	3-1	Costs in EMMA Study	3.9
	3-2	Pumping Station Annual O & M Costs	3.34
	3-3	Treatment Plant Annual O & M Costs	3.35
	3-4	Sludge Management Annual O & M Costs	3.38
	3-5a	Present Worth of Deer Island System	3.42
	3-5b	Present Worth of Nut Island System including Satellite Plants	3.43
	3-5c	Present Worth of Wet Weather Facilities	3.44
	3-6	Project ENR Indices	3.46
	3-7a	Apparent Real Dollar Cost of Deer Island System	3.48
	3-7b	Apparent Real Dollar Cost of Nut Island System including Satellite Plants	3.49
	3-7c	Apparent Real Dollar Cost of Wet Weather Facilities	3.50
	3-8	1976 Needs Survey for MSD Area	3.63
	3-9	1976 Needs Survey for Expanded MSD Area	3.64
	3-10	1976 Needs Survey for Regional Systems	3.65
	3-11	1976 Needs Survey for Peripheral Area	3.66

Chapter 3

ANALYSIS OF EMMA STUDY

During the Phase I preliminary study, the Wastewater Engineering and Management Plan for Boston Harbor-Eastern Massachusetts Metropolitan Area (EMMA Study) was being completed. The EMMA Study was published in 26 volumes and was prepared for the Metropolitan District Commission over a four-year period pursuant with the "three-party agreement." The Main Report dated March 11, 1976, was prepared by Metcalf & Eddy, Inc. Twenty-three separate technical data volumes dated October, 1975, were prepared by Metcalf & Eddy, Jason M. Cortell and Associates, Corps of Engineers, Whitman and Howard, Inc., Peat Marwick Mitchell & Co., Normandeau Associates, Inc., and ABT Associates, Inc., Reference 3.1.

The EMMA Study was prepared in cooperation with the EMMA Technical Subcommittee composed of eighteen members of the MDC, the New England Division of the U.S. Army Corps of Engineers, the Massachusetts DWPC, the U.S. EPA and the MAPC, in addition to eleven members of the EMMA Citizens Advisory Committee representing eleven sub-regional organizations.

A paper describing the EMMA Report was given by Martin Weiss and Jekabs P. Vittands at the Water Pollution Control Federation 49th Annual Conference October 1976 in Minneapolis, Minnesota, Reference 3.2.

A. PRELIMINARY ANALYSIS

The EMMA Main Report has been reviewed and a preliminary analysis was made as a part of the Phase I Study. The findings are reported as follows:

1. ADMINISTRATIVE PROCEDURES

Because the EMMA Study began virtually concurrently with the passage of PL 92-500, and because current construction grant program rules, regulations, guidance, and procedures were issued several years after the passage of PL 92-500, the EMMA Reports do not conform completely to the present requirements for facilities planning (Step 1) documents as otherwise might be expected if the study had begun recently. The EMMA Study was not intended to be a facilities plan. The purpose was to aid the MDC, after having the responsibility of providing sewer service for the past 80 years, to plan for the next 80 years. The EMMA Study actually serves as a preliminary feasibility study to define the scope of fifty-two separate projects on which facilities planning has now commenced and will continue over the next twenty years. It should be noted that the projects defined in the EMMA Recommended Plan are not intended to provide all of the facilities needed to comply with water pollution control requirements in the Metropolitan Sewerage District and will provide no facilities outside the future MSD service area.

It is reported that the study was locally funded by MDC and the U.S. Army Corps of Engineers. No application of grant assistance has been made according to EPA records. The study also does not appear in the clearinghouse list of Notice of Intent for federal assistance. Conformance to other requirements such as those of the National Environmental Policy Act (NEPA), and

I/I analysis, Relocation and Property Acquisition Assurances and many other milestones appear to still remain before the work considered therein can become eligible for funding assistance.

We were advised that it is intended that the three-step construction grants process will be followed separately for each of the fifty-two projects which compose the EMMA Recommended Plan.

The number one priority item in the EMMA Recommended Plan is a project for Primary Sludge Management for the plants at Deer and Nut Islands. Facilities Planning (Step 1) for that project was actually completed by Havens and Emerson in August 1973, Reference 3.3. It is reported that Step 2 design work had started for that project but has been terminated. The EPA determined that an EIS was necessary and EcolSciences, Inc. prepared a Draft EIS which was approved February 13, 1976 by the Regional Administrator, reference 3.4. The Final EIS on sludge management had not been released as of the date of this writing.

In an effort to determine what is considered to be the official status of the EMMA Report, we were provided with a copy of a letter dated September 13, 1976 addressed to Mr. Thomas C. McMahon, Director of DWPC and signed by John A. S. McGlennon, Regional Administrator of U.S. EPA. The first paragraph of that letter states:

> "We have reviewed the Eastern Massachusetts Metropolitan Area Study and the reports and attachments referenced in your letter of July 23 in accordance with Federal Regulations 40 CFR 131

> and believe it substantially
> meets the intent of those
> regulations. I am therefore
> approving the plan as the Water
> Quality Management Plan for
> Boston Harbor."

The EMMA Report therefore is officially considered to be the Basin Plan for Boston Harbor pursuant to Section 303 (e) of Public Law 92-500. What is not stated however is the boundary of the basin planning area for which the EMMA Report is the Basin Plan. It is not known if the boundary is the present MSD Service Area of 43 communities, the proposed future MSD Service Area of fifty-one communities, the entire EMMA Study Area of 109 communities, the fifty-three communities located in the drainage basins tributary to Boston Harbor, or some other boundary.

In the fall of 1976, EPA Region I embarked upon the preparation of an Environmental Impact Statement (EIS) for a portion of the facilities contained in the EMMA Recommended Plan, Reference 3.5. The EIS is being prepared on a 52-week schedule by the consulting firms of Greeley & Hansen and Environmental Assessment Council, Inc. The scope of the EIS includes attention to the following issues:

> a. The advisability of (2) Satellite treatment plants vs. the continued treatment of all the sewerage (sic) at Deer and Nut Islands,
>
> b. In light of the extensive filling that will be required adjacent to Nut Island to accommodate any expansion of the treatment facilities, alternate solutions for treatment of the

wastes generated in the southern portion of the MDC Service Area. should be discussed,

c. Subsequent to the completion of the EMMA Report the 1st District Court ordered the construction of an expanded prison at Deer Island. Alternate configurations for treatment facilities for the northern portion of the MDC System as well as the possibility of locating all of the secondary treatment facilities at Deer Island or another harbor island should be examined, and

d. The MDC has recommended sludge incineration. At the present time the Boston Air Quality Control Region (AQCR) has been classified as a non-attainment area for sulfur dioxide, particulates and photochemical oxidants. This represents a potential impediment to the incineration of secondary sludge. Great emphasis should be given in this EIS to a method of sludge disposal which allows for some recovery of this resource.

2. STUDY AREA

The EMMA MAIN REPORT identifies the Study Area as including 109 communities in eastern Massachusetts as encompassed by Interstate Route 495, the outer Belt around Boston Harbor. The EMMA Study Area includes 9 communities which are outside the boundary of the Metropolitan Area Planning Council (MAPC) 101 member communities, but the EMMA Study Area does not include one town, (Foxborough) which is in the MAPC. More important, however, is that the EMMA Study Area includes 17 cities and towns that are outside the 208 project Study Area involved in the MAPC Areawide Waste Treatment Management Plan.

The present MSD has forty-three member communities of which one town (Holbrook) is unsewered and contributing no sewage. Some developed area of other member communities are also unsewered. The MDC annual report indicates that 9 1/2-percent of the population in the member communities is not sewered.

It is found that the critical issue addressed in the EMMA Study is, as appears on page 1-4 of the Main Report:

> "What should be the ultimate MSD area and what communities should finally be served by the Deer and Nut Island treatment plants?"

The answer to that question, as shown by the EMMA Recommended Plan, is an increase in service from forty-three (43) to fifty-one (51) communities. The Plan proposes that five additional communities be served by new satellite plants and three additional communities be served by an expanded and upgraded plant at Deer Island. Several communities now served by Nut Island would also be served instead by the new Satellite Plants.

The remainder of the forty-nine communities in the Study Area are referred to as "peripheral areas."

The 1970 population of the 109 communities composing the 1,600 square mile EMMA Study Area is reported as 3,129,000. (In the Commonwealth of Massachusetts community boundaries are contiguous; that is, there is no county area outside the cities and towns.) Seventy-four percent of the population is sewered. Thirty-two percent of this area and 69 percent of the population is served by the present MDC system. Low and high population projections for the year 2000 are 3.7 and 3.9 million. Low and high population projections for the year 2050 are 4.0 and 5.1 million. A very significant decrease in some manufacturing is forecast, with less than half the present employment in wet industries by the year 2000.

3. WASTEWATER MANAGEMENT STRATEGIES

The Report assesses separately the opportunities for dry-weather flow management (Chapter 4) and for regulation of flows from combined sewers and during wet weather (Chapter 5).

a. Dry-weather Flow Management. Five basic concepts have been developed to define the service area limits of the Deer and Nut Islands treatment plants, as are diagrammed on Figure 3-1.

Sizes of needed facilities were determined by a process of flow quantification described in Techmical Data Volume 2. It is based on population and industrial activity, water consumption, type and age of sewers, and extraneous flow factors. Sizes were figured to serve into the future according to the type of facility:

Sewers	year 2020 to 2050
Tunnels	2050
Subaqueous pipelines	2050
Pump Stations	2000
Treatment Plants	2000

Treatment levels assumed for purposes of estimating costs were secondary treatment for Deer and Nut Islands or for land application. Advanced waste treatment was assumed to be required for plants which would discharge to inland rivers.

The EMMA Study excludes industries having separate discharges although it may be cost-effective for some on inland rivers to utilize MDC.

facilities after pre-treatment.

For each concept, approximate capital costs and annual operation and maintenance (O & M) costs for the entire Study Area were estimated and compared. A condensed summary of these costs for Concept 1 are shown in Table 3-1. Costs are noted as not including land and local collection sewers.

The five concepts were screened by qualitatively rating 23 factors in the areas of engineering (including monetary costs), water quality, socio-economic, public health, and design. Each factor was relatively weighted as to significance over a range of 1.6 to 5.6 (a ratio of 3 1/2 to 1).

Concept 4 ranked best when only environmental factors were considered. Concept 1 ranked best when only engineering factors were considered. Concept 1 was shown to have the lowest approximate total capital cost of $994 million and the second lowest approximate annual O & M cost, of $38 million. (Concept 3 had a lower annual O & M cost.) In the total overall rating, Concept 1 was clearly preferred. The approximate costs are stated as including inter-community interceptors and relief sewers as well as treatment plants.

Concept 4 was used to evaluate sludge management alternatives at six satellite plants. Alternatives were for incinerators at six, four, or two satellite plants; no other types of sludge management were reported except the possibility of resource recovery with other solid wastes. (The report states that sludge management for Deer and Nut Islands would be in accordance with the plans of Havens and Emerson, reference 3.3.) The economics of incineration was based on primary treatment and may be invalid for secondary treatment.

TABLE 3-1

COSTS IN EMMA STUDY

($ MILLION)

	Concept 1		Recommended Plan	
	Capital	Annual O&M	Capital	Annual O&M
Satellite Area Systems	$ 51	$ 4	135.1	5.2
Deer & Nut Island Systems, Dry Weather	396	13	450.3	16.5
Wet Weather Systems	279	4	270.0	3.9
SubTotal	726	21	855.4	25.6
Peripheral Area Systems	268	17	0	0
Total	$994	$38	$855.4	$25.6

Annual O&M costs of the Recommended Plan - $13 million in 1980 to $29.5 million in 2000.

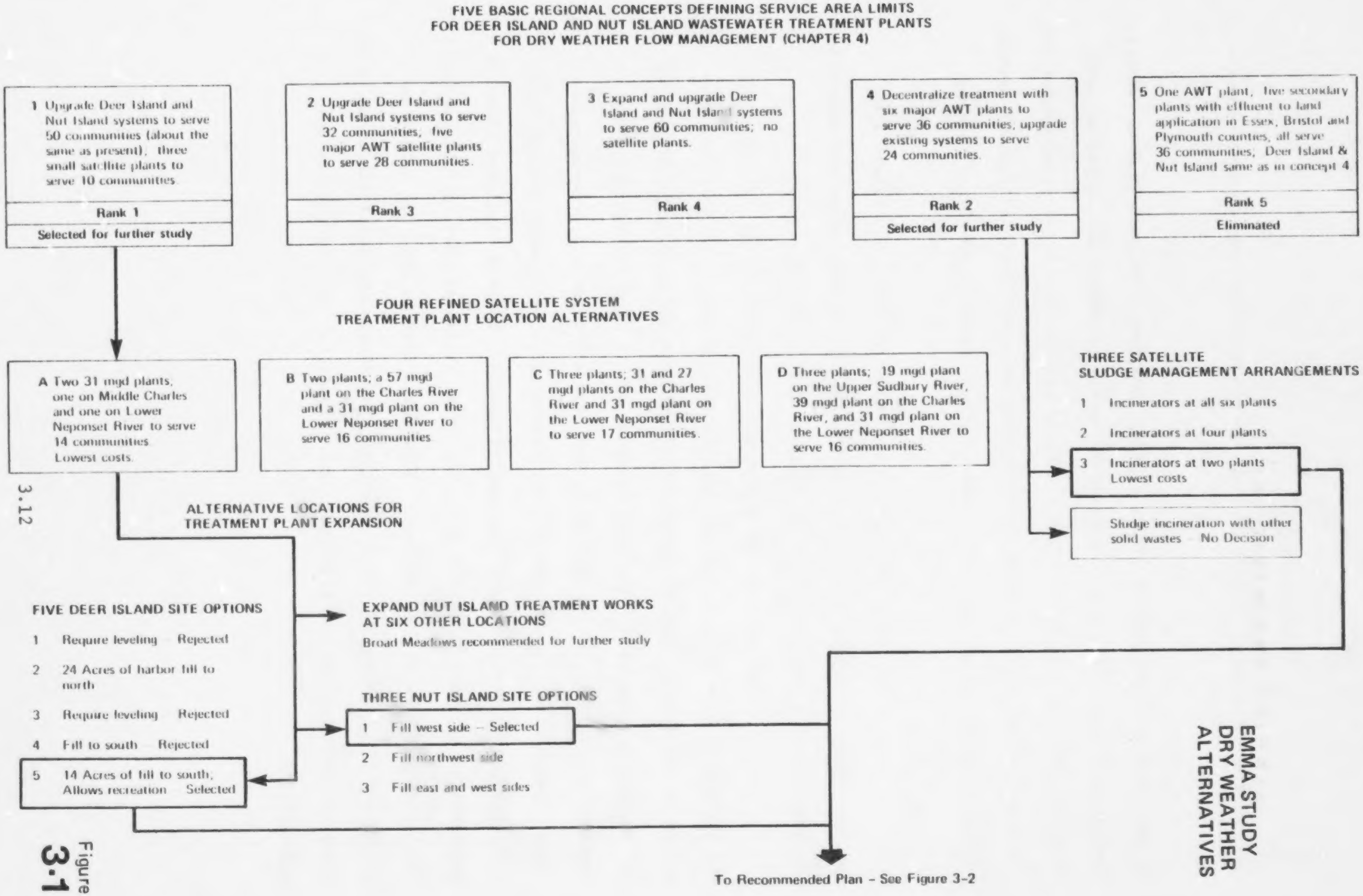
The recommended plan includes $265 million for secondary treatment facilities in Deer and Nut Island systems. Cost of the recommended plan without secondary treatment would be $590 million.

Concept 1 was selected for further study of alternative locatiosn of satellite plants. Satellite Concept 1 would upgrade the systems of the Deer and Nut Island service areas and add three satellite plants. The three satellite plants would be in the Charles River Basin, the Neponset River Basin, and on the Aberjona Rivers to serve 10 communities and thus reduce loadings to Nut Island, and for river flow augmentation. After refinement and screening of the four alternatives, Alternative A appeared to have the lowest costs. Alternative A was for two 31 mgd advance waste treatment (AWT) plants, to serve 14 communities. It is determined for the Aberjona River that the O & M costs alone would be over three times the cost of buying MDC water for augmenting the river flow, so this project alternative was not pursued further. The alternative of secondary treatment satellite plants with discharge to salt water was not considered.

Various options were considered for expanding the Deer and Nut Island Plants. Five site development schemes for developing treatment facilities on Deer Island were explored. After reviewing costs and environmental factors, options 1, 3, and 4 were eliminated from further consideration and option 5, designated the Land Use Intensive Alternate Plan, was selected as most appropriate. This plan would require 14 acres of fill on the south side of Deer Island. It would provide space for sludge management facilities and allow recreational uses on the Island. Six alternate locations were considered for expansion of treatment facilities to serve the southern sewerage area. These included abandonment of the Nut Island facilities and combining the treatment facilities at Deer Island, or locating new treatment facilities in the Broad Meadows Area of Quincy. Other considerations were to keep primary treatment at Nut Island and to develop secondary treatment facilities on Long, Peddocks, Moon, or Spectacle Islands. These options were all dropped except for the recommendation that further consideration be given to converting Nut Island to recreational use and locating a new treatment plant in the Broad Meadows area.

The report considers in some detail three Nut Island Site options. Option 1; with about 25 acres of fill in the west side, was selected for purposes of plant layout and preliminary cost estimates.

Chapter 4 of the report also includes a brief discussion of the peripheral area systems located outside the MDC area. Although not presented in any detail, capital costs of $268 million and annual O & M costs of $17 million are reported. The EMMA Recommended Plan for dry-weather flow management, as described in Chapter 6, has been analyzed on a geographical basis. Facilities recommended for dry-weather flow management include treatment works, pump stations, and interceptor sewers. We have tabulated these by geographical location in Figure 3-2. The total estimated cost for dry-weather facilities is shown as $585 million. This total cost is only one dollar per gallon per day capacity of all dry-weather flow management facilities, including those for bulk conveyance, treatment, and disposal or reclamation for flow augmentation.


FIVE BASIC REGIONAL CONCEPTS DEFINING SERVICE AREA LIMITS FOR DEER ISLAND AND NUT ISLAND WASTEWATER TREATMENT PLANTS FOR DRY WEATHER FLOW MANAGEMENT (CHAPTER 4)
1 Upgrade Deer Island and Nut Island systems to serve 50 communities (about the same as present); three small satellite plants to serve 10 communities.
Rank 1
Selected for further study
2 Upgrade Deer Island and Nut Island systems to serve 32 communities; five major AWT satellite plants to serve 28 communities.
Rank 3
3 Expand and upgrade Deer Island and Nut Island systems to serve 60 communities; no satellite plants.
Rank 4
4 Decentralize treatment with six major AWT plants to serve 36 communities; upgrade existing systems to serve 24 communities.
Rank 2
Selected for further study
5 One AWT plant, five secondary plants with effluent to land application in Essex, Bristol and Plymouth counties, all serve 36 communities; Deer Island & Nut Island same as in concept 4
Rank 5
Eliminated
FOUR REFINED SATELLITE SYSTEM TREATMENT PLANT LOCATION ALTERNATIVES
A Two 31 mgd plants, one on Middle Charles and one on Lower Neponset River to serve 14 communities. Lowest costs.
B Two plants; a 57 mgd plant on the Charles River and a 31 mgd plant on the Lower Neponset River to serve 16 communities.
C Three plants; 31 and 27 mgd plants on the Charles River and 31 mgd plant on the Lower Neponset River to serve 17 communities.
D Three plants; 19 mgd plant on the Upper Sudbury River, 39 mgd plant on the Charles River, and 31 mgd plant on the Lower Neponset River to serve 16 communities.
THREE SATELLITE SLUDGE MANAGEMENT ARRANGEMENTS
1 Incinerators at all six plants
2 Incinerators at four plants
3 Incinerators at two plants Lowest costs
Sludge incineration with other solid wastes – No Decision
ALTERNATIVE LOCATIONS FOR TREATMENT PLANT EXPANSION
FIVE DEER ISLAND SITE OPTIONS
1 Require leveling – Rejected
2 24 Acres of harbor fill to north
3 Require leveling – Rejected
4 Fill to south – Rejected
5 14 Acres of fill to south; Allows recreation – Selected
EXPAND NUT ISLAND TREATMENT WORKS AT SIX OTHER LOCATIONS
Broad Meadows recommended for further study
THREE NUT ISLAND SITE OPTIONS
1 Fill west side – Selected
2 Fill northwest side
3 Fill east and west sides
To Recommended Plan – See Figure 3-2

EMMA STUDY
DRY WEATHER
ALTERNATIVES

Figure
3·1

RECOMMENDED PLAN

From Figure 3-1

		Priority	$ Millions
A	**Expand Deer Island Service Area from 107 to 137 square miles (Add Lincoln, Lynnfield, and Weston)**		
	Sludge management for primary sludge	1	25.6
	I/I analysis and evaluation of North System	4	1.0
	Rehabilitate and enlarge primary plant to 400 mgd	6	41.9
	Add secondary treatment	8	150.0
	Sludge management for secondary sludge	9	28.1
	18 New interceptor and relief sewer projects	*	43.2
	Replace or rehabilitate 4 major pump stations	28-31	8.6
	Extension sewers to serve added towns	40, 42	4.2
	SUBTOTAL		$ 302.6
B	**Reduce Nut Island Service Area from 101 to 91 square miles (Remove Ashland, Framingham, Natick, Walpole, Stoughton, and part of Norwood, Canton, and Wellesley from Service Area. Add part of Hingham and Dover, serve Holbrook, not now served.)**		
	I/I analysis and evaluation of South System	2	1.0
	Rehabilitate and enlarge primary plant to 130 mgd, including outfall	5	50.5
	Add secondary treatment	7	86.7
	New interceptor - Lower Braintree	16	0.4
	Rehabilitate or replace 4 pump stations, force mains	17, 18, 23, 32, 38	6.7
	Extension Sewer - Westwood	48	2.4
	SUBTOTAL		$ 147.7
C	**Create new Middle Charles River Service Area of 38 square miles (To serve Ashland, Framingham, Natick, and part of Wellesley now served by Nut Island, plus Southborough, Hopkinton, Sherborn and part of Dover not now served.)**		
	New 31 mgd AWT plant	10	49.6
	New relief sewer - Framingham	14	22.5
	Two sewers to serve added towns	41,43	6.9
	SUBTOTAL		$ 79.0
D	**Create new Upper Neponset River Service Area of 27 square miles (To serve Walpole, Norwood, Stoughton, and part of Canton now served by Nut Island plant, plus Sharon not now served)**		
	New 25 mgd AWT plant	11	41.1
	Three new interceptor sewers	19, 20, & 45	13.8
	Sewer to serve Sharon	44	1.2
	SUBTOTAL		$ 56.1
	TOTAL DRY-WEATHER FLOW FACILITIES. 48 Projects (exclusive of combined sewer overflow facilities)		**$ 585.4**

IDENTIFIED OPTIONS

A **Staging Options**

1. Postpone satellite plants and secondary treatment at Deer Island and Nut Island
2. Postpone secondary treatment

B **Treatment Options**

1. Total ocean discharge
2. Ocean discharge in lieu of secondary treatment
3. Delete satellite plants
4. Postpone satellite plants

C **Consolidation Option**

1. Delete satellite plants (Priority 10 & 11)

   Build two new relief sewers
   Enlarge Nut Island

   Net extra cost - $17 million

---

* Priorities for the 18 new interceptor and relief sewer projects are 21, 22, 24, 25, 26, 27, 33, 34, 35, 36, 37, 39, 46, 47, 49, 50, 51, and 52.

RECOMMENDED PLAN
FOR DRY WEATHER FLOW

Kennedy Engineers
1977
Figure 3·2

Upon completion of the recommended plan, several options were identified as being worthy of further consideration. These would provide flexibility of staging, treatment, and a degree of consolidation.

The identifying staging options involve postponement of satellite plants and secondary treatment works only. The proposed MDC construction staging programs presented in the EMMA Report have since been revised to conform to the issued NPDES permit schedule. The principal final changes were to allow longer review periods between project steps.

The treatment options technically available are noted as total ocean discharge, ocean discharge in lieu of secondary treatment, and deletion or postponement of satellite plants. Total ocean discharge and ocean discharge in lieu of secondary treatment are shown to permit cost reductions of $117 and $100 million respectively.

The consolidation option is for providing two new relief sewers (add priority items 10A and 10B) to serve the Middle Charles and Upper Neponset satellite areas (delete priority items 10 and 11) for a net cost credit of $26 million. Including needed extra treatment capacity at Nut Island to serve the satellite areas, there would be a net cost increase of $17 million more than for the recommended plan with the two satellite plants.

These options are discussed in later chapters of this report.

b. Wet-Weather Flow Management. Chapter 5 of the EMMA main report assesses the problems associated with combined sewer overflow regulation and stormwater runoff control.

Combined sewers occur in a 38-square mile area around Boston

Harbor. The combined sewer area has a population of 900,000 and occurs principally in the Cities of Chelsea, Somerville, Cambridge, Brookline and Boston. Combined sewers also occur at Gloucester and Hingham. Data indicate that separate sewers in other areas have excessive inflow.

The extent of the problem is evidenced by the amount of overflow: 8,400 mgd peak rate during a design one-year storm for 8 hours, carrying 75,000 pounds of BOD into receiving waters from over one hundred sources. Coliform counts are predicted to be up to one-hundred million MPN per 100 milliliters. Some reports indicate combined sewage overflows at an average frequency of each three days throughout the year.

Objectives for regulation of combined sewer overflows as stated in EMMA Technical Data Volume 7 are:

> "1. Elimination of disease producing organisms,
> 2. Removal of floating matter, and
> 3. Reduction of solids.
> It is expected that removal of heavy metals and toxics will be accomplished through regulation of industrial discharges by source control."

There is no evidence presented that the facilities mandated in NPDES permits will meet the above objectives.

For purposes of sizing facilities and estimating their cost, a storm of one-year severity and six-hour duration was chosen as the design storm. For purposes of estimating the pollutional loads under storm conditions, a prior seven-day dry weather flow period of deposition was assumed.

The combined sewer problem and remedial needs are listed for five geographical locations around Boston Harbor:

1. Dorchester Bay,
2. Constitution Bay,
3. Charles River Basin,
4. Neponset River, and
5. Boston Inner Harbor.

As shown on Kennedy Engineers Figure 3-3, three alternatives to regulate pollution from overflows were discussed as being available and three general approaches were evaluated. The effectiveness of the alternatives in meeting the three stated objectives is not discussed. The sewer separation approach was estimated to cost $1.7 billion and was dismissed as not cost-effective. The previously proposed Deep Tunnel Plan was regarded as not presently viable because early commitment to that approach was needed and adoption now would cause abandonment of facilities existing and under construction. That plan included a long outfall into 100-foot deep water in Massachusetts Bay. The decentralized approach was recommended because it would continue present remedial practices and allow staged implementation. Space for location of needed facilities is noted as a drawback in high-density land use areas. Another key factor is the flexibility to take advantage of assimilative capacities of receiving waters. Treatment selected for costing purposes was:

"1. Chlorination with 15 minutes detention under design storm conditions (also providing for removal of solids and other pollutants through capture or sedimentation).
2. Screening for removal of large solids.
3. Skimming for removal of floatables."

Studies elsewhere reported indicate these facilities fail to meet stated objectives.* Three alternatives for consolidating the overflows into manageable groups were developed, facilities sized, and cost estimates were made. The impacts of the alternatives were predicted by using time-variable water quality and hydrodynamic models of portions of Boston Harbor developed by Hydroscience. Alternative 1, (not using Moon Island) was selected and four optional treatment systems were evaluated. The recommended course of action was made assuming dry weather flow secondary treatment at Deer and Nut Islands.

"Plans of Study" for facilities planning for regulating overflows at Dorchester Bay, Charles River Basin, Neponset River, and Boston Harbor are included in the recommended course of action.

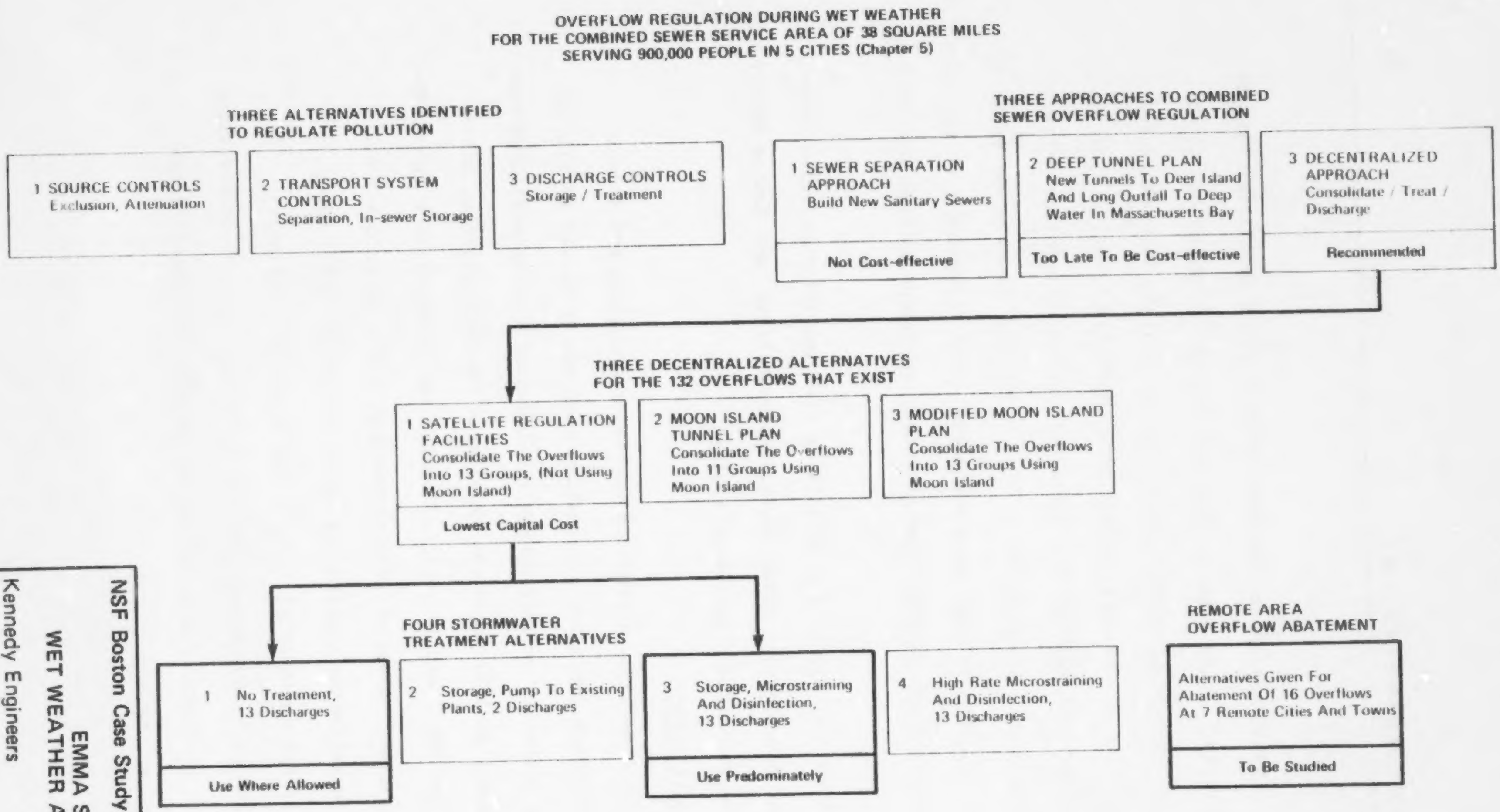
4. COST LEVELS

The EMMA Study determined approximate capital and annual operation and maintenance costs for alternative analysis of needed facilities. The costs used are stated as reflecting ENR (Engineering News-Record) Construction Cost Index values at 2200 which was considered representative in Boston for January 1975; the ENR Index is repriced weekly and is based on a hypothetical block of construction valued at $100 in the year 1913, Reference 3.6.

The estimates reported as costs for construction (Step 3) include an allowance for engineering (Step 1 and 2) and contingencies. The allowance varies from 25 to 50 percent depending upon the type of construction.

The preliminary cost estimates for the facilities in the Recommended Plan are at the same index value.

* (See Chapter 5.)


OVERFLOW REGULATION DURING WET WEATHER
FOR THE COMBINED SEWER SERVICE AREA OF 38 SQUARE MILES
SERVING 900,000 PEOPLE IN 5 CITIES (Chapter 5)
THREE ALTERNATIVES IDENTIFIED TO REGULATE POLLUTION
1 SOURCE CONTROLS Exclusion, Attenuation
2 TRANSPORT SYSTEM CONTROLS Separation, In-sewer Storage
3 DISCHARGE CONTROLS Storage / Treatment
THREE APPROACHES TO COMBINED SEWER OVERFLOW REGULATION
1 SEWER SEPARATION APPROACH Build New Sanitary Sewers
Not Cost-effective
2 DEEP TUNNEL PLAN New Tunnels To Deer Island And Long Outfall To Deep Water In Massachusetts Bay
Too Late To Be Cost-effective
3 DECENTRALIZED APPROACH Consolidate / Treat / Discharge
Recommended
THREE DECENTRALIZED ALTERNATIVES FOR THE 132 OVERFLOWS THAT EXIST
1 SATELLITE REGULATION FACILITIES Consolidate The Overflows Into 13 Groups, (Not Using Moon Island)
Lowest Capital Cost
2 MOON ISLAND TUNNEL PLAN Consolidate The Overflows Into 11 Groups Using Moon Island
3 MODIFIED MOON ISLAND PLAN Consolidate The Overflows Into 13 Groups Using Moon Island
FOUR STORMWATER TREATMENT ALTERNATIVES
1 No Treatment, 13 Discharges
Use Where Allowed
2 Storage, Pump To Existing Plants, 2 Discharges
3 Storage, Microstraining And Disinfection, 13 Discharges
Use Predominately
4 High Rate Microstraining And Disinfection, 13 Discharges
REMOTE AREA OVERFLOW ABATEMENT
Alternatives Given For Abatement Of 16 Overflows At 7 Remote Cities And Towns
To Be Studied

RECOMMENDED COURSE OF ACTION
BEGIN STEP I FOR COMBINED SEWER OVERFLOW REGULATION PROJECTS

		Priority	$Millions
A	Dorchester Bay Project	3	77
B	Charles River Project	12	84
C	Neponset River Project	13	23
D	Boston Inner Harbor Project	15	86
	TOTAL RECOMMENDED COSTS		$270

NSF Boston Case Study, Phase II Evaluation

EMMA STUDY
WET WEATHER ALTERNATIVES

Kennedy Engineers
1977

Figure 3·3

5. RECOMMENDED PLAN BY NEEDS CATEGORY

Another way of summarizing the items contained in the Recommended Plan is to group the elements in accordance with the definition of facilities categories used Nationally in the "Needs Survey," Reference 3.7. The capital cost of facilities grouped in such a manner is as follows:

a. Category I. This category is for facilities which would provide the legally required secondary treatment, (including primary treatment.)

In EMMA Recommended Plan they include priority items 1, 5, 6, 7, 8, and 9 at Deer and Nut Islands. They also include the portion of items 10 and 11 at the satellite plants which are for secondary treatment. The total capital cost, including steps 1, 2, and 3, is $433.8 million.

b. Category II. Facilities in this category are for the portion of the work needed to achieve effluent levels more stringent than secondary effluent levels.

In the EMMA Recommended Plan, it includes the portion of priority items 10 and 11 that would provide advanced waste treatment at the proposed satellite plants. The total capital cost including steps 1, 2, and 3 is $39.7 million.

c. Category III A. Facilities in this category are for correction of infiltration/inflow problems.

In the EMMA Recommended Plan priority items 2 and 4, are for I/I analyses of existing MSD facilities. The Step 1 cost is $2.0 million.

d. Category III B. This category is for replacement and/or major rehabilitation of existing sewage collection systems.

No costs are included in the EMMA Recommended Plan for this category.

e. Cateogry IV A. This category consists of costs for construction of collector sewer systems designed to correct violations caused by raw sewage discharges, seepage from septic tanks and the like.

No costs are included in the Recommended Plan for this category.

f. Category IV B. This category consists of costs for new interceptor sewers and transmission pumping stations necessary for the bulk transport of wastewaters.

In the EMMA Recommended Plan it includes thirty-eight items, priority numbers 14, 16 through 52. These are termed extension sewers, trunk sewers, relief sewers and force mains, as well as replacement or rehabilitation of eight existing MSD pumping stations. The total capital cost is $109.9 million.

g. Category V. Facilities in this category are to prevent periodic bypassing of untreated wastes from combined sewers to an extent they are violating water quality standards or effluent limitations.

In the EMMA Recommended Plan they include the four wet-weather flow regulation projects, priority numbers 3, 12, 13, and 15. The total capital cost is $270.0 million.

h. Category VI. This new category is for treatment and/or control of stormwaters pursuant to Public Law 93-243.

Treatment and/or control of stormwaters was not included in Needs Surveys prior to 1976, is not a part of the Clean Water Grant Program and was not in the Scope of the EMMA Study.

B. BASIC DESIGN CRITERIA

Basic criteria for treatment facilities contained in the Recommended Plan for design year 2000 are summarized in this Section. We have determined future contributing population for each service areas from Table 3-4 of the EMMA Main Report.

The service area of the present Metropolitan Sewerage District is 209 square miles in all or portions of 42 member communities. The two plants have a rated capacity of 455 mgd, 343 mgd at Deer Island and 112 mgd at Nut Island. The estimated population contributing sewage was was 1,980,000 according to the MDC FY 76 annual report. Early planning information considered the treatment capacity needed to serve 51 communities to be 562 mgd at five plants according to the EMMA Study Information Packet of May 1975. The final report shows recommended treatment capacity of 586 mgd at four plants, to serve the same area. A summary of plants and their rated average daily flow capacity is:

Plant	Present Flow	Present Capacity	Proposed May 1975	Final Recommended Plan
Deer Island	329	343	380	400
Nut Island	123	112	120	130
Middle Charles	0	0	30	25
Upper Neponset	0	0	30	31
Aberjona	0	0	2	6
TOTAL	452	455	562	586

For the entire expanded MSD service area of 51 communities, the 586 mgd (average daily flow) combined capacity of all treatment facilities is to serve a year 2000 population of 2,440,000. That is equivalent to a gross per capita allowance of 240 gallons per resident per day.

The first recommendation of House Document 1600, completed in 1936, was that the MDC provide devices for measuring sewage entering into the Metropolitan system at the connections of member communities. Because that was not done, sewage quantities have been predicted mathematically with a model based on planning principals and assumed calibration variables. The dry-weather flow quantification procedures were based principally on water consumption data with allowances made for industrial activity and infiltration and inflow.

1. DEER ISLAND SYSTEM

The Recommended Plan for Deer Island proposes to increase the north system capacity for the year 2000 from 343 to 400 mgd on an average daily flow basis (1975-76 average daily flow was 329 mgd). The peak capacity would be increased from 845 mgd to 930 mgd. The service area would be increased from 26 communities (or portions thereof) to 29 communities. The three extra communities have a year 2000 projected sewered population of 35,324 persons, with an average daily flow of 4.9 mgd and an estimated peak flow of 16.9 mgd. The balance of the extra capacity is for growth within present member communities until the year 2000, for flow from parts of member communities not now sewered, and an allowance due to projected increased per capita water use and sewage flow through the Phase I planning period, and has allowances for non-resident workers, industries connected to public sewers and for infiltration and inflow (I/I). The population to be served by Deer Island is projected to increase from 1,327,000 to 1,460,200 persons. The gross per capita capacity would increase from 248 to 274 gallons per sewered resident per day. A summary of Deer Island loadings for design year 2000 follows:

a. Influent. Proposed influent capacity is based on an expanded service area and the following design values:

Parameter	Design Value	Units
Service Area	137	square miles
Member Communities	29	number
Sewered Population	1,460,200	persons
Average daily flow	400	mgd
Peak flow	930	mgd
BOD, average load	555,000	pounds per day
BOD, peak load	1,176,000	pounds per day
SS, average load	511,000	pounds per day
SS, peak load	1,670,000	pounds per day

b. Primary Effluent. We have estimated mass emissions in future effluent from enlarged primary treatment facilities based on an average of 39% BOD removal and 52% suspended solids removal as follows:

Parameter	Emissions	Units
BOD	338,600	pounds per day
Suspended Solids	245,300	pounds per day
Settleable Solids	5,000	pounds per maximum day

Performance of primary treatment units was discussed in the previous chapter. Anticipated quality for primary effluent was not explicitly given in the EMMA Report except that BOD loading into aeration tanks including recycle is shown as 444,000, only a 20% reduction of the influent.* The above tabulated values are assumed and take into consideration present operations

* (30% removal less 10% return sludge load.)

and changed criteria proposed in the primary upgrading project. From an energy standpoint, primary treatment units which have virtually no power demand should be designed to remove greater amounts of BOD and SS, thus reducing the very high energy needs in the activated sludge process. As energy rates increase, the operating costs of activated sludge aeration systems will increase and it is desirable to maximize the removals made in primary treatment facilities. In general, each year later that a cost-effectiveness evaluation is made, it will become more economical to remove a greater fraction of pollutants with primary treatment facilities.

The NPDES permit issued to the MDC does not specify a level of performance for the effluent from the expanded primary plant, as noted in Chapter 2. The NPDES permit does indicate the discharge will be through the present outfalls in President Roads, although those outfalls have insufficient capacity.

c. Secondary Effluent. Effluent from facilities meeting secondary treatment could contain a monthly average of 30 mg/l of BOD and SS or fifteen percent of that of the influent, whichever is less. For Deer Island it appears the latter will govern. Mass emissions based upon eighty-five percent removal would be as follows:

Parameter	Emission	Units
BOD, average	83,250	pounds per day
SS, average	76,650	pounds per day
Bacteria	200/100 ml	fecal coliform
Bacteria	1000/100 ml	total coliform

The weekly average BOD and SS may be 50% greater. The weekly average coliform may be double. The weekly average settleable solids may be 335 pounds per day and on the maximum day may be 1000 pounds per day.

2. NUT ISLAND SYSTEM

Nut Island was serving a contributing population of 653,070 in twenty-one member communities, with an average daily flow of 123 mgd in fiscal year 1975-76. That was equivalent to a gross amount of 188 gallons per resident per day. It is reported that industrial contribution is minor. The expanded southern part of the EMMA Recommended Plan would be served by three plants in the future. The three plants would have a combined average daily flow capacity of 186 mgd, with 130 mgd handled at Nut Island. The new service area for the southern part of the District would increase from 21 to 26 member communities with a projected population of 979,900 in the year 2000.

The five new member communities have an estimated year 2000 sewered population of 27,000 persons. The combined average daily flow capacity allowance for the three southern plants comes to an average of 190 gallons per connected resident per day.

a. Influent. The combined influent capacity for the three proposed southern plants is based on the following design values:

Parameter	Design Value	Units
Service area	156	square miles
Member communities	26	number
Sewered population	979,900	persons
Average daily flow	186	mgd
Peak flow	453	mgd
BOD, average load	300,400	pounds per day
BOD, peak	688,800	pounds per day
SS, average load	365,900	pounds per day
SS, peak	725,800	pounds per day
BOD, avg, concentration	194	mg/l
SS, avg,	236	mg/l
BOD, avg, per capita	0.307	pounds per day
SS, avg, per capita	0.374	pounds per day

Influent loadings for the individual plants are as follows:

Parameter	Nut Island	Middle Charles	Upper Neponset	Units
Average daily flow	130	31	25.2	mgd
Peak flow	310	75.6	67.4	mgd
BOD, average load	201,000	57,400	42,000	pounds per day
SS, average load	281,000	47,400	37,500	pounds per day
Nitrogen load	-	5,430	4,400	pounds per day
Phosphorus load	-	3,100	2,600	pounds per day
Sewered population	674,900	181,000	124,000	persons (approx.)
Flow per person	193	215	171	gal. per capita per day

b. Primary Effluent. We have estimated the effluent loadings from primary treatment portions of the facilities. They are expected to contain the following average daily emissions:

Parameter	Nut Island	Middle Charles	Upper Neponset	Units
BOD	140,000	40,000	29,000	pounds per day
SS	130,000	19,000	15,000	pounds per day

Water quality of primary effluents is not defined, but BOD is given as 160,800 (including recycle) for Nut Island. The Nut Island project includes some outfall work that may change the discharge location from Quincy Bay, although the change is not recognized in the NPDES permit. It is observed that the NPDES permit for the existing primary plant would allow 190,000 pounds per day of BOD and up to 1,080 pounds per day of settleable solids in a 130 mgd discharge from Nut Island.

c. Secondary Effluent. Effluent from secondary treatment facilities could contain up to the following average daily constituents:

Parameter	Nut Island	Middle Charles	Upper Neponset	Units
BOD	30,150	7,760	6,300	pounds per day
SS	32,550	7,100	5,625	pounds per day
Bacteria	200/100ml	200/100ml	200/100ml	fecal coliform
Ammonia Nitrogen	-	3,800	3,080	pounds per day
Phosphorus	-	2,170	1,820	pounds per day

The water quality of the secondary effluent from the satellite plants was not given in the EMMA Report or in the NPDES permit.

d. Advanced Treatment Effluent. Effluent from the proposed advanced waste treatment plants are reportedly planned to have effluent characteristics as follows:

Parameter	Concentration
BOD	5 mg/1
SS	5 mg/1
Fecal Coliform	200/100 ml
pH	6.0-9.0
Ammonia Nitrogen	Less than 1 mg/1 as N
Phosphorus	Less than 1 mg/1 as P

With these criteria, effluent emissions to the Rivers would not exceed the following:

Parameter	Middle Charles	Upper Neponset	Units
Average daily flow	31	25.2	mgd
BOD	1300	1050	pounds per day
SS	1300	1050	pounds per day
Ammonia Nitrogen	260	210	pounds per day
Phosphorus	260	210	pounds per day

The loadings listed above do not include the effect of bypasses.

The NPDES permit does not establish numerical limits for the effluents from the satellite plants if they are built. The permit indicates the effluent limits will be in accordance with load allocations developed by basin planning pursuant to Section 303 (e) of Public Law 92-500.

The exact location of the satellite plants and their discharge points has not been determined. A site selection study, with public participation, was begun in the fall of 1976. For purposes of this Study, we are assuming one would be located on the North bank of the Charles River near the Penn Central Railroad in Needham (elevation 110) and the other on the East bank of the Neponset River near the Interstate 95 Neponset Street interchange in Canton (elevation 60).

3. COMBINED SEWER OVERFLOWS

The EMMA Study reports a combined sewer area in Boston, Brookline, Cambridge, Chelsea and Somerville of 38 square miles, about one-fifth of the MDC service area and serving one-half of the Study Area population. Flows from 69 selected overflow points in the core area were quantified using hydrologic models. A design storm of 1- year severity and 6-hour duration was chosen for purposes of sizing facilities. This resulted in an estimated peak quantity of overflow of 8,400 mgd for a 1-year storm.

The quality of the overflows was estimated based on a 7-day dry weather condition prior to the design storm event (with no flushing of solids and were reported as follows:

Parameters	Emissions	Units
BOD	75,100	pounds
Suspended Solids	795,480	pounds
Coliform	10^3 to 10^8	MPN per 100 ml

The existence of other bacterial pollution, grit, floating solids and liquids, heavy metals and toxics in the overflows was also recognized. At the time the EMMA Study was conducted there were no water quality standards for combined sewer overflows. Definitive Effluent Limitations for combined sewer overflows still have not been established. The EMMA Report gives the following major objectives for overflow regulation:

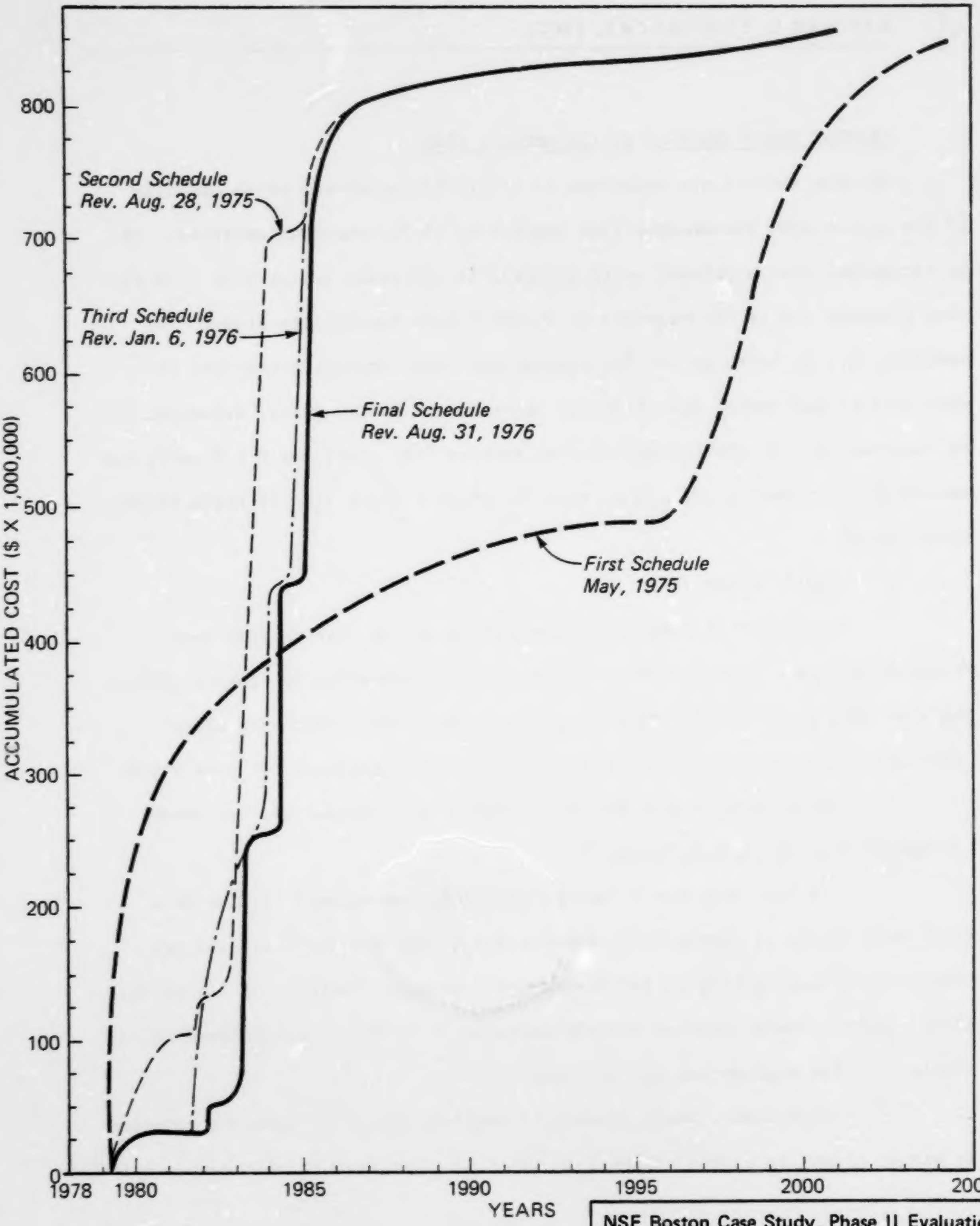
> "Elimination of disease
> producing organisms,
>
> Removal of floating matter,
> and
>
> Reduction of solids."

Because those objectives do not specifically define practical design criteria, the cost estimates for treatment were tentatively based on facilities similar to those at the existing Cottage Farm Chlorination and Detention Station and with design detention of 15 minutes. Authors of the EMMA Report recognize that future combined sewer overflow treatment requirements are a major uncertainty in the Recommended Program, reference 3.2.

Discussion of combined sewer overflows did not include present frequent by-passing and overflows due to intentional flow restriction necessitated by restricted pumping or treatment capacity at Deer Island.

C. CONSTRUCTION STAGING PROGRAM

During the course of the EMMA Study at least four different construction staging programs were developed. The original staging program was published in an information packet in May 1975, reference 3.8. This was revised as of August 28, 1975 and published in the EMMA Study Main Report, Reference 3.1. It is found in Chapter 6 and is footnoted as "initial issue." The August 28, 1975 staging program was further revised as of January 6, 1976 and published as Attachment C of the Draft (Proposed), NPDES Permit (No. MA0102351) for MDC, Reference 3.9. The fourth and latest revision as of August 31, 1976 was to conform with NPDES Permit which was issued in August 1976, Reference 3.10. These four construction staging programs are presented graphically in Figure 3-4. The three revised staging programs differ from the original schedule principally because the original staging program planned for secondary treatment to occur significantly later in the project (or not at all). The later versions reflect a greater period of time between steps for purpose of project review by the State and EPA. It is noted that in terms of total ENR 2200 dollars capital cost estimates there is little difference between the four schedules. This indicates that the original plan has changed little and only the timing has changed. The major impact of changing the timing is that the original staging schedule would have a far smaller present worth as it was not front end loaded.



NSF Boston Case Study, Phase II Evaluation

CONSTRUCTION STAGING COSTS
VS. TIME

Kennedy Engineers
1977

Figure **3·4**

D. PRESENT WORTH ANALYSIS OF RECOMMENDED PLAN

In this section the objective is to provide a present worth analysis of the entire EMMA Recommended Plan consisting of 52 component projects. It is recognized that a present worth analysis is performed during Step 1 facilities planning and is not required in a preliminary feasibility study. The analysis will be based on the EPA regulations which include accounting for both capital and annual operation and maintenance (O & M) costs, Reference 3.11. As directed by U.S. EPA regulations, neither capital costs nor O & M costs are escalated for probable inflation, even though this could significantly affect comparisons.

1. BASIS OF ANALYSIS

All reported costs are based on the Boston Construction Cost Engineering News - Record (ENR) Index of 2200 corresponding to January 1975. The same base year and ENR Index is used throughout this report to allow correlation between this report and the EMMA studies reviewed for this study.

In accordance with EPA requirements, an interest rate of seven percent is used in this analysis. *

The cost data basis (except for sludge management) is the EMMA Study Main Report of March, 1976, Reference 3.1, and the final revised MDC Construction Staging Program for Wastewater Management Projects of August 31, 1976. Capital costs reported therein included 25 to 50 percent, depending on complexity, for engineering and contingencies.

O & M costs, while apparently analyzed in depth, were not reported in enough detail to enable analysis in terms of fixed and variable components

* (as was appropriate at the time of the EMMA study.)

of the total annual O & M cost. Pumping station estimated annual O & M costs given in the EMMA Report are summarized in Table 3-2. Comparison of the totals shown in Table 3-6 indicates a decrease from 1980 and 1990 of 4.4 percent and an increase from 1990 and 2000 of 3.8 percent. The overall decrease in cost between 1980 and 2000 is only 0.6 percent. While differences between reported years for some individual pumping stations vary, the aggregate total varies only a minor amount. The average anuual O & M values of the three reported years were used as a fixed annual O & M cost for the Kennedy Engineers analysis.

Wastewater treatment plant annual O & M costs for the Upper Neponset River and Middle Charles River facilities were reported in enough detail to justify analysis in terms of fixed and variable components. However wastewater treatment plant annual O & M costs for the Nut Island and Deer facilities were not sufficiently detailed to allow analysis in terms of fixed and variable cost components. Estimated annual O & M costs for the various treatment facilities as given in the EMMA Report are summarized in Table 3-3. As shown in Table 3-3 the annual O & M costs for Nut Island WWTP and Deer Island WWTP are not connected to a specific year, as are those costs for Upper Neponset River WWTP and Middle Charles River WWTP. In addition, review of the MDC Construction Staging Program shows that the former plants beginning of operation dates (i.e. end of construction dates) for the First (primary treatment extension) and Second (secondary treatment extension) Phases are only ten months apart. Finally the combined annual O & M cost for Nut Island and Deer Island facilities is significantly larger than the combined annual O & M cost for Upper Neponset River and Middle Charles River facilities.

TABLE 3-2

PUMPING STATION ANNUAL OPERATION AND MAINTENANCE COSTS

(Dollars per Year)

EMMA Priority No. (1)	Pumping Station	Estimated Annual O & M Cost (2)		
		Year		
		1980	1990	2000
	Deer Island Service Area			
30	Alewife Brook	$ 185,200	$ 187,800	$ 189,400
29	Charlestown	251,900	237,600	239,600
28	East Boston Steam	210,200	154,400	154,600
31	East Boston Electric	13,900	13,900	13,900
(3)	Reading	97,800	103,400	109,700
	SUBTOTAL	759,000	697,100	707,200
	Nut Island Service Area			
17	Braintree-Weymouth	211,100	221,000	244,400
38	Hingham	80,200	90,900	99,400
32	Houghs Neck	(4)	(4)	(4)
23	Quincy	201,400	186,100	190,700
(3)	Squantum	16,300	16,900	18,300
	SUBTOTAL	509,000	514,900	552,800
	TOTAL	$1,268,000	$1,212,000	$1,260,000

Notes

(1) See Figure 3-2.

(2) Based on ENR 2200. Source is Reference 3.1.

(3) On-going project.

(4) Included with Nut Island Plant O & M costs.

TABLE 3-3

TREATMENT PLANT ANNUAL OPERATION AND MAINTENANCE COSTS

(Thousand Dollars per Year)

	Annual O & M Cost for Treatment Plant							
	Upper Neponset River(2)		Middle Charles River(3)		Nut Island(4)(6)		Deer Island(5)(6)	
Item	1990	2000	1990	2000	First	Second	First	Second
Manpower								
Operation & Maintenance	725	790	790	880	1,024	1,451	2,189	2,862
Fuel and Electric Power								
Fuel	17	17	18	18	-	100	146	190
Electric Power	735	948	948	1,105	-	1,050	1,809	4,041
Chemicals								
Chlorine	32	39	39	48	486	324	1,496	998
Ferric Chloride	77	84	84	104	-	-	-	-
Alum	440	533	536	664	-	-	-	-
Lime	62	67	67	84	-	-	-	-
Maintenance								
Plant	172	172	207	207	337	664	453	1,175
TOTAL	2,260	2,650	2,689	3,110	2,027	3,589	6,093	9,266

Notes:
(1) Based on ENR 2200. Source is Reference 3.1.
(2) EMMA Priority No. 11.
(3) EMMA Priority No. 10.
(4) EMMA Priority No's. 5 and 7 for First and Second Phase respectively.
(5) EMMA Priority No's. 6 and 8 for First and Second Phase respectively.
(6) Sludge management annual O & M costs are in addition to these.
(7) First Phase is primary treatment extension and Second Phase is secondary treatment extension.

Based on these facts, it was decided to treat the annual O & M costs for the wastewater treatment facilities as fixed annual costs. Thus, the average of the reported 1990 and 2000 annual O & M costs for Upper Neponset River and Middle Charles River plants were used in this analysis. The reported annual O & M costs for the Nut Island and Deer Island plants were as reported, except that the difference between the first and second phase was used as representative of the second phase incremental cost. This allows direct comparison of the estimated cost impact of adding secondary treatment to primary treatment.

Sludge management annual O & M costs for Phase I (primary sludge management) and Phase II (secondary sludge management) must be added to the annual O & M costs for Nut Island and Deer Island sewage facilities combined. These sludge management costs are summarized in Table 3-4. The basis for the costs is the Sludge Management Study of June 1973 for MDC, reference 3.3. This reference was unavailable at the time of writing but certain pertinent data were supplied by NSF, Reference 3.12. The reported capital costs of combined Phase I and Phase II Sludge Management was $42,202,000, while that in the EMMA Study was $53,667,000, Reference 3.1. However, the $42,202,000 did not include engineering and overhead costs. We have assumed therein that the difference between the two values represents the inclusion of engineering and overhead in the EMMA Study value. It has been further assumed herein that the Sludge Management Study reported costs are on the same ENR 2200 basis. Phase II annual O & M costs shown in Table 3-4 were determined by Kennedy Engineers from the difference between the reported Phase I and Phase II combined and the Phase I costs. The values shown in Table 3-4 were used in this analysis as fixed or uniform annual O & M costs. Priority items 10 and 11 include sludge management for the satellite plants.

Pipeline annual O & M costs for interceptors, sewers, and force mains were not included for the EMMA Recommended Plan with the statement that it was felt any new pipes could reasonably remain virtually maintenance-free during the first few years of service. However, in a cost-effectiveness analysis over a relatively long 20-year period, some O & M costs need to be assigned to new pipelines. Average values commonly used for large cities are 0.3 percent and 0.5 percent of construction costs for gravity lines and force mains, respectively. Capital costs for pipelines in the EMMA Project reportedly include 25 percent for contingencies and engineering, Reference 3.1. Thus, the corresponding annual O & M cost factors used in this analysis are 0.24 percent and 0.40 percent of capital costs for raw sewage gravity lines and force mains, respectively. For force mains and outfalls conveying treated effluent, we added no annual O&M costs.

Note: EPA reports the Sludge Management Costs were $46,202,000 as of June 1973, later trended to January 1975 price levels.

TABLE 3-4

SLUDGE MANAGEMENT ANNUAL OPERATION AND MAINTENANCE COSTS FOR NUT ISLAND AND DEER ISLAND

(Dollars per Year)

Item	Estimated Annual O & M Cost(1)		
	Phase I and II Combined	Phase I(2)	Phase II(2,3)
Fuel and Power	631,700	329,000	302,700
Chemicals	575,000	273,200	301,800
Maintenance	375,700	146,000	729,700
Manpower	1,570,500	1,120,000	450,500
Recovered Energy Cost	-795,000	-318,000	-477,000
TOTAL (Rounded)	2,358,000	1,550,000	808,000

(1) Assumed to be based on ENR 2200. Source is Reference 3.3.

(2) Phase I is primary treatment sludge management and Phase II is secondary treatment sludge management.

(3) Equal to difference between reported Phase I and II combined cost and reported Phase I cost.

2. PRESENT WORTH ANALYSIS METHODOLOGY

Capital cost present worth values were generated in the following manner. The date of capital cost expenditure was assumed to occur at midpoint of construction. Interest during construction was based on the interest charged to the capital cost over a period equal to one-half the construction period. Depreciation was based on straight line depreciation to zero value of salvage at the end of the assumed service life (30 years for treatment facilities and pumping stations, 50 years for pipelines) and the useful life (the period between end of construction and December, 2000). For example, a pumping station (service life 30 years) having a capital cost of $3,000,000 and an end of construction period date of December, 1980 (useful life 20 years) would have a December 2000 value depreciated to $1,000,000 ($3,000,000 x (30-20)/30), also called "salvage" value. The net present worth of an item capital cost is then the sum of capital cost and interest during construction times the single payment present worth factor for the period from the midpoint of construction date to the base year date (January, 1975) minus the depreciation times the single payment present worth factor for the period of base year to December 2000.

Annual O & M cost present worth values were generated by multiplying the fixed (uniform) annual cost times the uniform series present worth factor for the period from end of construction to December, 2000 times the single payment present worth factor for the period of January, 1975 (base year date) to the end of construction date.

Equivalent annual costs are found by multiplying the present worth value times the capital recovery factor of 7 percent interest per annum over 25 years (1975 through 2000).

The preceeding description of the present worth analysis methodology is smilar to the EPA requirements for a cost-effectiveness analysis to compare alternatives as a part of any Step 1 Facilities Planning study. However in this chapter only the recommended plan is being analysed for present worth because the EMMA Study is not a Step 1 study, but instead is a preliminary study. As such a present worth analysis was not required for the study.

3. PRESENT WORTH ANALYSIS

Using the preceding cost data and present worth analysis methodology, a present worth analysis was performed on the entire EMMA Study project list. The results of this analysis are summarized in Table 3-5. The 52 EMMA Recommended Projects are grouped in Table 3-5 into the four general service areas (Nut Island, Deer Island, Upper Neponset River and Middle Charles River) and the stormwater projects.

As seen in Table 3-5 the total Recommended Project present worth is approximately $603,000,000 or about $252,000,000 less than the total project capital cost. This is to be expected as a major amount of the capital costs (priority numbers 5 through 12 totaling $531,930,000) are scheduled to be expended about eight years after the initial date (January, 1975), for which the present worth factor is approximately 0.6. Correspondingly high undepreciated present worth values are also subtracted from the capital cost present worth. Finally, the major portion of the annual O & M costs occur relatively far into the future. An acceleration of implementation timetable would significantly increase present worth costs estimates.

The total present worth value of $603,000,000. represents the present worth cost of the EMMA Recommended Plan projects. As previously mentioned, those projects do not provide all the facilities required to meet present water pollution control regulations. During Step I Facilities Planning changes in the costs can be expected as individual detailed planning studies and cost-effectiveness analyses are completed. This present worth analysis represents approximate relative costs to be expected for the projects as presently planned and estimated. It also can serve as a reference point for the alternative project analyses performed in Chapter 10 of this report. A detailed cost estimate can only be done from complete construction plans and specifications.

TABLE 3-5a

PRESENT WORTH OF DEER ISLAND SYSTEM
(Dollars)

EMMA Priority No.	Project Description	Capital Cost (1) (2)	Annual O&M Cost (1)	Present Worth (1)(2)(3)(4)
1	Sludge Management (Primary)	$25,573,000	$1,550,000	$ 30,312,000
4	I/I Study (North System)	1,012,000	0	907,000
6	Rehab & Expand Primary Treat.	41,900,000	6,093,000	54,904,000
8	Add Secondary Treat.	150,000,000	3,173,000	101,737,000
9	Sludge Management (Secondary)	28,094,000	808,000	19,219,000
21	No. Charles Metro Sewer	1,271,000	2,900	695,900
22	Millbrook Valley Sewer	3,771,000	8,700	1,958,000
24	North Metro Sewer	1,165,000	2,700	247,400
25	Chelsea Branch Sewer	145,000	300	67,600
26	Stoneham Ext. Sewer	349,000	800	153,900
27	Stoneham Trunk Sewer	145,000	300	63,400
28	East Boston Steam P.S.	1,460,000	173,100	1,373,000
29	Charlestown P.S.	6,000,000	243,000	3,532,000
30	Alewife Brook P.S.	712,000	187,500	1,118,000
31	East Boston Elec. P.S.	365,000	13,900	215,500
33	Somerville Medford Branch Sewer	4,500,000	10,400	1,568,200
34	S. Charles Relief Sewer	2,670,000	6,100	836,300
35	Wakefield Branch Sewer	838,000	1,900	296,200
36	S. Charles River Sewer	8,428,000	19,400	2,641,300
37	Cummingsville Branch Sewer	1,012,000	2,300	264,300
39	Revere Ext. Sewer	3,413,000	7,900	681,000
40	Lynnfield Ext. Sewer	367,000	800	71,600
42	Weston-Lincoln Ext. Sewer	3,832,000	8,800	614,000
46	Wilmington Ext. Sewer	2,964,000	6,800	253,800
47	N. Metro Sewer	475,000	1,100	45,900
49	Wakefield Trunk Sewer	4,754,000	10,900	292,900
50	Wakefield Branch Sewer	177,000	400	15,300
51	S. Charles Relief Sewer	2,911,000	6,700	125,200
52	S. Charles River Sewer	4,250,000	9,800	107,000
	SUBTOTALS (Deer Island)	$302,553,000	$12,351,000	$224,317,000

See footnotes at end of Table 3-5c.

TABLE 3-5b

PRESENT WORTH OF NUT ISLAND SYSTEM
(Including Satellite Plants, $)

EMMA Priority No.	Project Description	Capital Cost (1) (2)	Annual O&M Cost (1)	Present Worth (1)(2)(3)(4)
2	I/I Study (South System)	$ 983,000	$ 0	$ 908,000
5	Rehab & Expand Primary Treat. (incl. outfall)	50,536,000	2,027,000	39,186,000
7	Add Secondary Treatment	86,700,000	1,562,000	55,031,000
16	New Interceptor (Lower Braintree)	400,000	900	236,000
17	Braintree-Weymouth P.S.	2,920,000	226,000	3,229,000
18	Hingham Force Main	534,000	2,000	319,400
23	Quincy P.S. & F.M.	2,220,000	193,000	2,245,000
32	Houghs Neck P.S.	203,000	(5)	86,000
38	Hingham P.S.	890,000	90,200	436,800
48	Westwood Ext. S.	2,350,000	5,400	208,900
	SUBTOTALS (Nut Island)	$147,736,000	$4,107,000	$101,886,000
	CREATE NEW MIDDLE CHARLES RIVER SERVICE AREA AND CONSTRUCT PLANT			
10	New 31 MGD AWT Plant	$49,600,000	$2,773,000	$42,443,000
14	Framingham Ext. Sewer	22,461,000	51,700	14,542,000
41	Ashland-Hopkington Ext. S.	4,459,000	10,300	828,800
43	Southboro Ext. Sewer	2,421,000	5,600	333,900
	SUBTOTALS	$78,941,000	$2,841,000	$58,148,000
	CREATE NEW UPPER NEPONSET RIVER SERVICE AREA AND CONSTRUCT PLANT			
11	New 25 MGD AWT Plant	$41,100,000	$2,338,000	$ 35,374,000
19	Stoughton Ext. Sewer	1,090,000	2,500	629,200
20	Walpole Ext. Sewer	11,894,000	27,400	6,520,000
44	Sharon Ext. Sewer	1,218,000	2,800	156,500
45	Stoughton Ext. Sewer	827,000	1,900	87,900
	SUBTOTALS	$56,129,000	$2,373,000	$ 42,768,000
	TOTAL (Nut Island System)	$282,806,000	$9,321,000	$202,802,000

See footnotes at end of Table 3-5c.

TABLE 3-5c

PRESENT WORTH OF WET WEATHER FACILITIES
(Dollars)

EMMA Priority No.	Project Description	Capital Cost (1) (2)	Annual O&M Cost (1)	Present Worth (1)(2)(3)(4)
	COMBINED SEWER OVERFLOW PROJECTS			
3	Dorchester Bay C.S.O.	77,000,000	1,100,000	$ 53,798,000
12	Charles River C.S.O.	84,000,000	1,200,000	57,598,000
13	Neponset River C.S.O.	23,000,000	400,000	16,188,000
15	Inner Harbor C.S.O.	86,000,000	1,200,000	48,253,000
	SUBTOTALS	$270,000,000	$3,900,000	$175,837,000
	GRAND TOTAL (52 Projects)	$855,359,000	$25,572,000	$602,956,000

Notes:

(1) Based on ENR 2200, January, 1975. Sources are Ref. 3.1 and 3.3.
(2) Includes contingencies, engineering, legal and administrative costs.
(3) Based on seven percent interest per annum.
(4) Includes salvage and interest during construction.
(5) Costs included with Priority Numbers 5 and 7.

E. APPARENT REAL DOLLAR COSTS OF RECOMMENDED PLAN

The EPA Cost-Effectiveness Analysis Guidelines prohibit inclusion of inflation in a present worth analysis. The basic assumption is that inflation will have a smilar impact on all prices and, therefore, all alternatives, effecting no change in the final results. However, at some point inflation should be studied if for no other reason that to provide an order-of-magnitude basis for future budgeting. To this end NSF has requested Kennedy Engineers to look separately at the apparent real dollar cost of the Recommended EMMA Plan. That is, to look at the potential impact of inflation on the recommended project.

The inflation rate used herein is 8.6 percent per annum, as derived from EPA Region I projections of ENR indices through the year 1995. These projections are summarized in Table 3-6. Kennedy Engineers has projected the ENR index for the years 1996 through 2000 in the same manner as used by the EPA. The present worth costs presented herein are still based on ENR 2200 January, 1975 dollars.

Present worth costs for this analysis were found in the same manner as for the preceding analysis except as follows. The various costs were excalated from their base date (January, 1975) to their expenditure date at the compounded inflation rate of 8.6 percent per annum. The escalated cost is then brought back to the base date present worth value using the single payment present worth factor at seven percent interest per annum. The net effect is that O & M costs require a separate calculation of present worth for each year the annual O & M cost occurs. It should be pointed out that

TABLE 3-6

PROJECTED ENR INDICES

Year	Projected ENR Index		Ratio to 1975
	EPA Region I(1)	KE Inc.	
1975	2200(2)		1.000
76	2390		1.086
77	2595		1.180
78	2820		1.282
79	3060		1.391
1980	3320		1.509
81	3605		1.639
82	3915		1.780
83	4250		1.932
84	4615		2.098
1985	5010		2.277
86	5440		2.473
87	5910		2.686
88	6420		2.918
89	6970		3.168
1990	7570		3.441
91	8220		3.736
92	8930		4.059
93	9700		4.409
94	10,530		4.786
1995	11,435		5.198
96		12,420	5.645
97		13,485	6.130
98		14,645	6.657
99		15,905	7.230
2000		17,275	7.852

(1) From Mr. Daniel K. O'Brien, EPA Region I.
(2) Level of EMMA Study

estimates of energy costs are not separately available for each project. It is obvious that escalation of energy costs will greatly exceed other O & M costs. Therefore, escalation of total O & M costs will be relatively understated. On this basis, an energy intensive treatment process may, in the future, become prohibitive in operating cost. The results of this analysis are summarized in Table 3-7 following the same format used in Table 3-5. As seen in Table 3-7 the estimated total present worth of apparent real dollar cost of the EMMA planned projects in ENR 2200 dollars is approximately $1,550,000,000 when inflation is accounted for. This apparent real dollar cost is approximately twice the estimated total capital cost. It is important at this point to keep in mind that this value has been estimated in only a simplified manner. The analysis purposely did not include a sophisticated long range economic analysis based on forecasting international, national and local economic indicators and trends, variable interest and inflation rates, technological advances, fiscal and monetary policies, nor socio-political trends to name a few factors to be accounted for in such an analysis. The sole purpose of this inflation analysis is to provide an order-of-magnitude estimate of the apparent real dollar expenditures to be expected when inflation takes its toll on future projects.

TABLE 3-7a

APPARENT REAL DOLLAR COST OF DEER ISLAND SYSTEM
(Dollars)

EMMA Priority No.	Project Description	Capital Cost (1) (2)	Escalated Capital Cost (2)(3)	Present Worth (1)(2)(3)(4)(5)
	EXPAND DEER ISLAND FACILITIES AND SERVICE AREA			
1	Sludge Management (Primary)	$25,573,000	$35,329,000	$ 27,012,000
4	I/I Study (North System)	1,012,000	1,229,000	41,982,000
6	Rehab & Expand Primary Treat.	41,900,000	78,263,000	173,508,000
8	Add Secondary Treat.	150,000,000	294,622,000	235,700,000
9	Sludge Management (Secondary)	28,094,000	55,181,000	48,590,000
21	No. Charles Metro. Sewer	1,271,000	2,178,000	71,328,000
22	Millbrook Valley Sewer	3,771,000	6,894,000	3,849,000
24	North Metro. Sewer	1,165,000	2,372,000	1,194,000
25	Chelsea Branch Sewer	145,000	289,000	145,600
26	Stoneham Ext. Sewer	349,000	742,000	351,000
27	Stoneham Trunk Sewer	145,000	308,000	144,200
28	East Boston Steam P.S.	1,460,000	3,383,000	4,933,000
29	Charlestown P.S.	6,000,000	14,204,000	11,039,000
30	Alewife Brook P.S.	712,000	1,650,000	4,414,000
31	East Boston Electric P.S.	365,000	846,000	648,000
33	Somerville-Medford Branch Sewer	4,500,000	12,123,000	4,502,000
34	S. Charles Relief Sewer	2,670,000	7,840,000	2,612,000
35	Wakefield Branch Sewer	838,000	2,162,000	814,000
36	S. Charles River Sewer	8,428,000	24,749,000	8,248,000
37	Cummingsville Branch Sewer	1,012,000	3,310,000	963,000
39	Revere Ext. Sewer	3,413,000	13,846,000	2,914,000
40	Lynnfield Ext. Sewer	367,000	1,457,000	302,800
42	Weston-Lincoln Ext. Sewer	3,832,000	17,691,000	2,993,000
46	Wilmington Ext. Sewer	2,964,000	18,501,000	1,663,000
47	N. Metro. Sewer	475,000	2,720,000	277,200
49	Wakefield Trunk Sewer	4,754,000	32,344,000	2,087,000
50	Wakefield Branch Sewer	177,000	1,058,000	95,300
51	S. Charles Relief Sewer	2,911,000	21,588,000	967,700
52	S. Charles River Sewer	4,250,000	34,354,000	901,000
	SUBTOTALS (Deer Island)	$302,553,000	$691,233,000	$654,178,000

See footnote at end of Table 3-7c.

TABLE 3-7b

APPARENT REAL DOLLAR COST OF NUT ISLAND SYSTEM

(including Satellite Plants, $)

EMMA Priority No.	Project Description	Capital Cost (1) (2)	Escalated Capital Cost (2)(3)	Present Worth (1)(2)(3)(4)(5)
	EXPAND NUT ISLAND FACILITIES AND REDUCE SERVICE AREA			
2	I/I Study (South System)	$ 983,000	$ 1,168,000	$ 1,129,000
5	Rehab & Expand Primary Treat. (incl. outfall)	50,536,000	94,394,000	100,924,000
7	Add Secondary Treatment	86,700,000	170,292,000	130,580,000
16	New Interceptor (Lower Braintree)	400,000	643,000	408,000
17	Braintree-Weymouth P.S.	2,920,000	4,793,000	8,554,000
18	Hingham Force Main	534,000	858,000	563,000
23	Quincy P.S. & F.M.	2,220,000	4,177,000	6,572,000
32	Houghs Neck P.S.	203,000	470,000	209,000
38	Hingham P.S.	890,000	3,173,000	2,051,000
48	Westwood Ext. Sewer	2,350,000	14,050,000	1,308,000
	SUBTOTAL (Nut Island)	$147,736,000	$294,018,000	$252,298,000
	CREATE NEW MIDDLE CHARLES RIVER SERVICE AREA AND CONSTRUCT PLANT			
10	New 31 MGD AWT Plant	$49,600,000	$92,645,000	$113,073,000
14	Framingham Ext. Sewer	22,461,000	35,823,000	24,964,000
41	Ashland-Hopkinton Ext. Sewer	4,459,000	18,886,000	3,711,000
43	Southboro Ext. Sewer	2,421,000	11,923,000	1,734,000
	SUBTOTAL	$78,941,000	$159,277,000	$143,482,000
	CREATE NEW UPPER NEPONSET RIVER SERVICE AREA AND CONSTRUCT PLANT			
11	New 25 MGD AWT Plant	$41,100,000	$76,769,000	$ 97,205,000
19	Stoughton Ext. Sewer	1,090,000	1,789,000	1,113,000
20	Walpole Ext. Sewer	11,894,000	21,279,000	12,547,000
44	Sharon Ext. Sewer	1,218,000	6,129,000	829,000
45	Stoughton Ext. Sewer	827,000	4,536,000	4,549,000
	SUBTOTAL	$56,129,000	$110,502,000	$116,243,000
	TOTAL (Nut Island System)	$282,806,000	$563,797,000	$512,023,000

See footnote at end of Table 3-7c.

TABLE 3-7c

APPARENT REAL DOLLAR COST OF WET-WEATHER FACILITIES
(Dollars)

EMMA Priority No.	Project Description	Capital Cost (1) (2)	Escalated Capital Cost (2)(3)	Present Worth (1)(2)(3)(4)(5)
	COMBINED SEWER OVERFLOW PROJECTS			
3	Dorchester Bay C.S.O.	$ 77,000,000	$131,949,000	$108,506,000
12	Charles River C.S.O.	84,000,000	143,944,000	118,370,000
13	Neponset River C.S.O.	23,000,000	39,413,000	34,058,000
15	Inner Harbor C.S.O.	86,000,000	182,802,000	119,249,000
	SUBTOTAL	$270,000,000	$498,108,000	$380,183,000
	GRAND TOTAL (52 Projects)	$855,359,000	$1,753,138,000	$1,546,384,000

Notes:

(1) Based on ENR 2200, January, 1975.
(2) Includes contingencies, engineering, legal and administration costs.
(3) Based on 8.6 percent per annum escalation to midpoint of construction.
(4) Based on 7 percent per annum interest. Includes salvage and interest during construction for construction costs.
(5) Based on 8.6 percent per annum escalation to year of occurrence and 7 percent interest, for operation and maintenance costs.
(6) Costs included with Priority Numbers 5 and 7.

F. APPARENT UNMET NEEDS

Our review of the EMMA documents indicates that a comprehensive study has been conducted of the major municipal wastewater problems in the Study Area. The EMMA Report recommends a $855.4 million plan to serve two-thirds of the population residing in one-third of the Study Area.

This section attempts to summarize some facilities which apparently are needed to satisfy overall goals but for which costs have not been included in the EMMA Recommended Plan. The apparent unmet needs of the recommended plan are listed separately for inside and outside the expanded MSD service area.

1. INSIDE EXPANDED MSD SERVICE AREA

The EMMA Report identified several items in the expanded service area that are not included in the Recommended Plan. We have listed municipal items by "Needs Category." Approximate costs are shown where they were given in the EMMA Report.

a. Category I, Secondary Treatment Facilities. The EMMA Recommended Plan includes facilities in this category for pumping, secondary treatment and disposal at four locations: Deer Island, Nut Island, and at two satellite sites. Rehabilitation of existing primary plants and new sludge management facilities for Deer and Nut Island are included. No other plants would be needed.

The EMMA Recommended Plan has not included costs for possible additional items which we have discussed in Chapter 2 and which may be added as facilities planning and EIS requirements are met, as follows:

(1) Covering the Deer Island sedimentation tanks as part of the primary rehabilitation project priority.

(2) Increase maximum pumping and treatment capacity at Deer Island to intermittently handle a portion of the peak flows, as a part of projects designated priority 6 and 8. (This may reduce some of the needs in Category V.)

(3) A change of site from Nut Island to another location may entail extra costs for projects designated 5 and 7.

b. Category II, More Stringent Treatment. No grant eligible items in this category appear to be needed in addition to those at the two satellite plants which provide more than secondary treatment.

Because the Aberjona River AWT reclamation plant has already been eliminated as not a cost-effective solution, the cost of that facility is not added. Provision of alternative sources of water is considered ineligible for grant assistance.

c. Category III A, I/I Correction. The Recommended Plan does not include costs for the Step 2 and Step 3 correction work which cannot be determined until the present Step 1 work is completed. The Recommended Plan does not include costs for I/I correction work known to be needed in the sewer systems of the member communities. For comparison it should be noted that there are 5,326 miles of local sewers of the member communities connected to the 226 miles of MDC interceptors.

d. Category III B, Major Sewer System Rehabilitation. Work in this category is known to be needed especially in the older core area communities. For example the City of Boston has submitted grant applications for four projects totaling $54.6 million for rehabilitation of the Boston Main Interceptor, the Mt. Vernon Street Sewer and the East Side Interceptor, Reference 3.13. Somerville needs approximately $10 million worth of sewer rehabilitation, Reference 3.14.

An item not appearing in the Recommended Plan is facilities for metering and sampling user connections to the sewerage system. The MDC Annual Report states there are 1,862 user connections to the MDC system as of June 30, 1976.

e. Category IV A, New Collectors. New collector sewers will be needed for future MSD member communities of

Lincoln,
Lynnfield,
Weston,
Sharon,
Dover,
Southborough,
Sherborn, and
Hopkinton.

The Town of Holbrook is presently a member of MSD but is unsewered. In addition there are many member communities which are only partially sewered.

To give an indication of the extent of the unmet needs of present member communities for sewers, the following listing is from the preliminary output of the MAPC 208 study expressed in terms of existing unsewered population, Reference 3.15.

Community	% unsewered
Ashland	88
Bedford	55
Braintree	2
Burlington	51
Canton	48
Dedham	14
Framingham	21
Hingham	80
Holbrook	100
Lexington	23
Milton	6
Natick	41
Needham	14
Norwood	1
Randolph	50
Reading	40
Revere	6
Stoneham	5
Stoughton	24
Wakefield	12
Walpole	68
Waltham	25
Wellesley	19
Westwood	66
Weymouth	49
Wilmington	99
Woburn	10

(The remaining sixteen communities, including Boston, are noted as 100% sewered.) No costs for sewers in the above listed communities are included in the Recommended Plan.

f. Category IV B, New Interceptors. The costs for several projects designated in the EMMA Report as "on-going" are presumably already financed locally and are not included in the recommended plan. These include

Reading extension sewer,
Upper Neponset Valley sewer,
Braintree-Weymouth extension sewer,
Squantum pump station ($1.3 million) and
Reading pump station and force main ($3.0 million).

Thirty-eight interceptors are included in the Recommended Plan. Additional costs would be needed only if it is found to be necessary to build additional interceptors to assist in solving the combined sewer overflow problems.

g. Category V, Correction of Combined Sewer Overflows. The EMMA Recommended Plan does not include the cost to abate combined sewer overflows identified therein as existing in seven communities remote from and not feasible to consolidate with the four main combined sewer overflow regulation projects. There is also a major unanswered question on the required solution or degree of treatment needed for the four regulation projects.

In addition, the facilities used as a basis of estimation Category V costs for EMMA projects may be inadequate to provide the degree of treatment stated as the criteria. More extensive and expensive facilities may be required.

h. Category VI, Treatment and/or Control of Stormwaters. The EMMA Recommended Plan does not include any facilities for this category but the Report indicates that costs of such needed facilities as $456 million. This may be the major problem in the future.

i. Related Municipal Items. No amount is included for other related municipal items as:

(1) Land, easements and rights-of-way costs, which generally are not grant eligible.

(2) EIS Preparation Costs, which are borne entirely by the EPA.

(3) Extra capacity for industries with separate discharge who may elect to connect to public sewers rather than continue direct discharge.

(4) Operation and maintenance costs and costs to administer the source control and other continuing management programs.

As further evidence that the MSD does not necessarily serve all municipal wastewater needs of its 43 member communities, it is observed that at least 39 MSD member communities have been issued NPDES permits because of continuing raw sewage discharges, overflows, and/or bypasses which are at least in part due to inadequate capacity in the MSD system.* Not all needed corrections of these deficiencies is included in EMMA cost estimates.

j. Non-Municipal Items. There are no costs included in the EMMA Recommended Plan for facilities needed to abate various other types of point and non-point sources of non-municipal wastewaters. Many items in this category are being addressed by the MAPC 208 Study, Reference 3.16. Many must be entirely financed by private or local public funds. They include the following:

(1) Direct discharges into water bodies from private institutions, commerce and industry.

(2) Oil spillage, ballast and bilge waters, and wastes from ships, pleasure boats and marinas.

---

* (In 1978, EPA states that only 9 communities had permits.)

(3) Seepage or leachate from failing land disposal systems septic tanks as well as septage. MAPC advises that this is a particular problem outside the MDC service area due to beneficial use of groundwaters.

(4) Leachate from sanitary landfills and dumps. MAPC reports that this is also a big problem in the Study Area.

(5) Drainage of road salt.

(6) Erosion and siltation from extractive industry, construction operations and hydrographic modifications.

(7) Runoff from agricultural operations, of minor importance in the Study Area.

(8) Pretreatment and self-monitoring of waste from institutional, commercial and industrial sources connected to public sewers. This may be a very significant item but not to the clean water grant program.

2. PERIPHERAL AREA

As has been noted previously, the Study Area outside the expanded MSD service area is identified as the peripheral area. This area is composed of some fifty-eight communities, some unsewered, some sewered with no treatment, and some with less treatment than required.

The EMMA Study indicates that the peripheral area system needs are $268 million capital cost, with $17 million annual O & M cost. It is presumed that these costs are for municipal facilities and do not include ineligible costs and costs for non-municipal facilities, stormwater facilities, and facilities to correct non-point source waste problems.

In the final section of this chapter we will report the unmet needs of the Study Area as ascertained by the National Needs Survey.

G. LOCAL RESULTS OF NEEDS SURVEYS

Throughout the nation, estimates of the cost of construction of publicly-owned treatment works needed to meet the 1983 goals of the Federal Water Pollution Control Act are determined annually or biennually. The estimates are based upon surveys conducted pursuant to Section 516 (b)(2) of the Act and are submitted to the Congress by the EPA. The results are used as a basis for allocating the allotment of grant funds to the States.

The construction grants program started in 1957 under the original Act of 1956. Authorizations were $50 million dollars for each of the first five years, increasing up to $6,000 million in Fiscal year 1974.

The total costs for all facilities needed nation-wide in October 1973 was reported to be $60,023 million, up from $10,000 million in 1969. "Clean Water," the EPA Report of June 1974 to Congress, Reference 3.17, states:

> "The reasons for this large increase include a more comprehensive survey of facilities, minimum treatment requirements at the secondary level, more stringent water quality requirements, better estimating procedures, and inflation."

In the 1974 Needs Survey, estimates of costs for similar facilities (categories I-V) grew to $107,436 million plus an additional amount of $235,006 million for new category VI, treatment and/or control of stormwaters, for a total of $342,442 million at 1973 price levels, Reference 3.18. Data in that survey show facilities needs in the State of Massachusetts as follows:

Category		Million Dollars
I	Secondary Treatment	587
II	More Stringent Treatment	205
IIIA	I/I Correction	33
IIIB	Sewer system rehabilitation	25
IVA	New collector sewers	755
IVB	New interceptors	533
V	Combined sewer overflows	824
VI	Stormwater	3,121
	TOTAL	$6,085 million

That amount, exclusive of Category VI is $420 per capita and 2.7597 percent of the nationwide total.

Data from the 1974 and earlier surveys are not available for portions of the State. The EPA is now required biennially to update estimates of needs. The 1976 updates for Categories I through IV were conducted by Dames & Moore. The 1976 updates for Categories V and VI were conducted by James, Jones & Goulding Inc. and Black, Crow and Eidsness, Inc. The two 1976 surveys employed entirely different methodology, but both are at price levels representing January 1976 dollars. This is equivalent to an ENR index value of 2331 for Boston, or 1.06 times the cost level in the EMMA Report.

For facilities Categories I-IV, needs were estimated in accordance with an Operation Manual prepared especially for the 1976 update, Reference 3.19. We were advised that representatives of each municipal discharger, (a community official or their consulting engineer) were contacted. Twenty-nine kinds of data were determined for each discharger and recorded on a computerized form, with the cost estimate entered for each category. Categories III and IV are split as in 1974. The costs are then summarized by State, by EPA Region, and for the Nation. For Categories I through IV, the needs files were assessed for all cities, towns and districts especially for this study. Twenty-three cities and towns did not appear. Of those, the communities of Arlington, Ashland and Watertown are now served by the MSD, although for Ashland, the MDC annual report shows only 9% of the Area and 23% of the population was sewered in 1976. Littleton, Sharon and Sherborn were not found in the needs files. Those three communities are proposed in the EMMA Report to be annexed to the MSD. They have no sewers at present and a sewered population of 16,355 projected for the year 2000, for which new collection sewers are presumed to be needed. The other seventeen communities are in the peripheral area. Eight of these are projected by the EMMA Report to have a sewered population of 42,537 persons while the balance are shown as unsewered by the year 2000.

The needs for Categories V and VI were developed using a needs estimation computer model applied throughout the country. The model was developed from the literature and a detailed analysis of ten specific urbanized areas. Boston was not one of the ten areas of detailed study. Using site-specific input and more than 400 mathematical steps, needs were then determined for 320 urbanized areas nationwide. One of these was Boston. The Boston combined sewer area is shown on the program input as 21,200 acres (equivalent to 33.1 square miles) with a population of 335,000. The model used 128 storms per year and an average annual rainfall of 42.77 inches for the Boston case. For Category VI, the area used was 631 square miles.

The 1976 Survey of Needs for Control of Pollution from Combined Sewer Overflows and Stormwater Discharges was prepared for the EPA By Jordan, Jones &

Goulding, Inc. and Black, Crow and Eidsness, Inc., Reference 3.20. That survey developed, using defined assumptions and consistent nationwide methodology, cost estimates to attain three different water quality criteria, aesthetics, fish and wildlife, and recreation, the highest being those needs necessary to achieve the recreation water quality criteria. Needs were determined for 320 urbanized areas and resulted in costs at the January 1976 level for each state, for combined sewer overflow correction (Category V) and also for control of stormwater discharges (Category VI).

In that survey, it was assumed that certain non-structural measures such as street sweeping would remove 55% of the pollutants. Treatment facilities were then determined based on various levels of criteria for settleable solids, floatables, BOD, suspended solids, dissolved oxygen, coliform reduction by chlorination, and/or dechlorination as considered approximate for each location. In that survey, it was assumed that about twice the average dry weather flow would go to the dry weather flow treatment plants. Excess wet-weather flow up to 98 percent of the total would go to new control facilities where there are combined sewers (Category V), and up to 90 percent where there are not combined sewers (Category VI). The excess over those amounts would bypass control facilities and discharge untreated.

Data made available from 1976 Needs Survey selected specifically for the Study Area have been analyzed for this study, References 3.21 and 3.22. Results are as follows:

		Million Dollars		
	Facilities Category	Expanded MSD	Peripheral Area	Study Area
I	Secondary Treatment	62.2	62.7	124.9
II	More Stringent Treatment	0	31.5	31.5
III A	I/I Correction	0.9	1.3	2.2
III B	Sewer System Rehabilitation	45.0	0.9	45.9
IV A	New Collector Sewers	109.9	257.9	367.8
IV B	New Interceptors	53.4	89.6	143.0
	Sub-total	271.4	443.9	715.3
V	Combined Sewer Overflows	198.2	0	198.2
VI	Stormwater	1,912.5*	0 *	1,912.5*
	Total	2,382.1	443.9	2,826.0

Detailed cost estimates of needs from the 1976 update were provided for each community and for each regional agency which could be accessed from the survey data. Table 3-8 contains their estimate of the costs within the present MSD service area. Except for the incinerators, no NDC needs are shown. Table 3-9 contains the costs for the expanded MSD service area. Table 3-10 shows the costs for communities in the peripheral area that are members of a regional sewerage system. Table 3-11 contains the costs for the other peripheral communities.

See NOTE on page 3.80

* There was insufficient information to split Category VI by area.

TABLE 3-8

1976 NEEDS SURVEY FOR MSD AREA
(million dollars)

Community	I	II	III		IV		TOTAL
			A	B	A	B	
Hingham	0	0	0	0	0	4.9	4.9
Randolph	0	0	0	0	5.3	1.8	7.1
Weymouth	0	0	0	0	2.2	0.3	2.5
Braintree	0	0	0	0	0.04	0.1	0.1
Woburn	0	0	0	0	0	0	0
Canton	0	0	0	0	7.8	0.6	8.4
Holbrook	0	0	0	0	3.2	0.5	3.7
Wellesley	0	0	0	0	3.7	2.4	6.1
Wakefield	0	0	0	0	0	1.4	1.4
Burlington	0	0	0	0	0	0	0
Lexington	0	0	0	0	0.5	0	0.5
Wilmington	0	0	0	0	0	1.9	1.9
Bedford	0	0	0.01	0	8.3	4.5	12.8
Framingham	0	0	0.1	0	0.1	2.0	2.2
Natick	0	0	0.03	0	9.0	0	9.0
Cambridge	0	0	0	0	0	0	0
Stoughton	0	0	0	0	16.3	3.6	19.9
Boston	0	0	0	45.0	0.5	0.4	45.9
Chelsea	0	0	0	0	0	0	0
Everett	0	0	0.1	0	0	0.2	0.3
Malden	0	0	0	0	1.6	4.4	6.0
Medford	0	0	0	0	0	0	0
Melrose	0	0	0.1	0	0	1.3	1.4
Newton	0	0	0.1	0	0	1.0	1.1
Quincy	0	0	0.5	0	0	1.2	1.7
Brookline	0	0	0	0	0	0	0
Dedham	0	0	0	0	3.2	0.2	3.4
Needham	0	0	0	0	0.1	0	0.1
Norwood	0	0	0	0	0.2	0.05	0.2
Stoneham	0	0	0	0	0.2	0.1	0.3
Westwood	0	0	0	0	2.6	2.5	5.1
MSD, Deer I.	62.2	0	0	0	0	0	62.2
Waltham	0	0	0	0	0.8	10.2	11.0
Walpole	0	0	0	0	9.6	2.3	11.9
Belmont	0	0	0	0	0	0	0
Somerville	0	0	0	0	0	0	0
Revere	0	0	0	0	0	0	0
Winchester	0	0	0	0	0	0	0
Milton	0	0	0	0	1.7	0.1	1.8
Reading	0	0		0.9	0.9	0.9	1.8
Existing MSD TOTALS	62.2	0	0.9	45.0	77.8	49.0	234.9

TABLE 3-9

1976 NEEDS SURVEY FOR EXPANDED MSD AREA

(Million dollars)

Community	Cost Estimates by Facilities Category I	II	IIIA	IIIB	IVA	IVB	Total
Communities recommended to be annexed to MSD:							
Lincoln							0
Lynnfield	0	0	0	0	11.3	0.7	12.0
Weston	0	0	0	0	1.2	0.8	2.0
Dover							0
Hopkinton	0	0	0	0	5.4	0.5	5.9
Sharon							0
Sherborn							0
Southboro	0	0	0	0	14.2	2.4	16.6
Total	0	0	0	0	32.1	4.4	36.5
Plus MSD and existing member communities:							
Total Table 3-8	62.2	0	0.9	45.0	77.8	49.0	234.9
TOTAL	62.2	0	0.9	45.0	109.	53.4	271.4

See NOTE on page 3.80

TABLE 3-10

1976 NEEDS SURVEY - REGIONAL SYSTEMS
(Million dollars)

Community	I	II	III		IV		TOTAL
			A	B	A	B	
SOUTH ESSEX SEWER DISTRICT							
Beverly	0	0	0.03	0	3.4	7.2	10.6
Peabody	0	0	0	0	14.2	2.4	16.6
Salem	0	0	0.4	0.3	6.7	4.6	12.0
Danvers	0	0	0	0	5.5	0.3	5.8
Marblehead	0	0	0.1	0	1.0	0.1	1.2
SUBTOTALS	0	0	0.5	0.3	30.8	14.6	46.2
CHARLES RIVER POLLUTION CONTROL DISTRICT							
Bellingham	0	0	0	0	3.9	1.9	5.8
Franklin	0	0	0.1	0	4.3	1.5	5.9
Medway	0	0	0	0	5.1	1.9	7.0
SUBTOTALS	0	0	0.1	0	13.3	5.3	18.7
LYNN REGIONAL SYSTEM							
Lynn	32.1	0	0	0	0	0	32.1
Saugus	0	0	0	0	11.4	2.2	13.6
Nahant	0	0	0	0	0.1	2.9	3.0
SUBTOTALS	32.1	0	0	0	11.5	5.1	48.7
Total Regional Systems	32.1	0	0.6	0.3	55.6	25.0	113.6

Note: All of the above peripheral area communities are indicated as not having secondary treatment facilities now, all are expected to not meet secondary treatment levels by 7-1-77, and all are shown to not need more stringent treatment.

TABLE 3-11

1976 NEEDS SURVEY FOR PERIPHERAL AREA
(Excluding members of regional systems)
(Million dollars)

	Treatment Level									
	Second now	Sec. by 7/1/77	More stringent	I	II	III		IV		TOTAL
Community						A	B	A	B	
Acton	No	No	Yes	0	7.8	0	0	5.8	1.5	15.1
Marlboro E.	Yes	Yes	Yes	0	0	0	0	2.4	0.7	3.1
Marlboro W.	Yes	Yes	Yes	0	0	0	0	3.1	6.5	9.6
Concord	Yes	Yes	Yes	0	4.8	0	0	3.9	1.8	10.5
Ipswich	No	No	No	0	0	0	0	8.4	0	8.4
Rockland	No	No	Yes	0	4.6	0	0	7.5	0.1	13.2
Scituate *	Yes	No	Yes	0	2.9	0	0	10.5	2.6	16.0
Swampscott	No	No	No	2.5	0	0	0	0	0	2.5
Billerica *	Yes	No	No	0.3	0	0	0	40.0	3.5	43.8
Chelmsford	No	No	No	7.3	0	0	0	28.7	4.0	40.0
Gloucester	No	No	No	10.2	0	0	0	8.7	1.8	20.7
Hull	No	Yes	No	0	0	0	0	7.6	0	7.6
Hudson	Yes	Yes	Yes	0	1.4	0	0	1.7	0.6	3.7
Milford	Yes	Yes	Yes	0	4.5	0.5	0	0	1.3	6.3
North Reading	No	No	No	0	0	0	0	9.2	5.1	14.3
Marshfield	No	No	No	3.1	0	0	0	4.5	8.4	16.0
Holliston	No	No	No	0	0	0	0	4.2	3.1	7.3
Hanover	No	No	No	2.6	0	0	0	10.1	2.8	15.5
Rockport	Yes	Yes	No	0	0	0	0	2.4	1.6	4.0
Cohasset	Yes	Yes	No	1.9	0	0	0	8.0	0.7	10.6
Northborough	No	No	No	0	0	0	0	3.1	1.8	4.9
Essex	No	No	Yes	0	0.8	0	0	1.0	1.2	3.0
Manchester	Yes	Yes	No	0	0	0	0	0.7	0	0.7
Medfield	No	Yes	Yes	0	0	0.01	0	4.5	1.4	5.9
Maynard	Yes	Yes	Yes	0	0	0.2	0.6	0.5	0	1.3
Westborough	Yes	Yes	Yes	0	4.7	0.01	0	4.1	1.5	10.3
Millis	No	No	No	0.5	0	0.003	0	3.4	2.3	6.2
Westford	No	No	No	0	0	0	0	2.4	0	2.4
Avon	No	No	No	0	0	0	0	5.6	0.3	5.9
Sudbury	No	No	No	2.2	0	0	0	6.0	3.6	11.8
Peripheral		TOTALS		30.6	31.5	0.7	0.6	202.3	64.6	330.3

* (It is not clear how a community can have secondary treatment in 1976 and not by 7/1/77.)

A comprehensive survey of needs for wastewater facilities is also being made on a regional basis by the MAPC as a part of their areawide study for the 92 community 208 project. Preliminary cost estimates are shown in their 1976 interim output. We have re-grouped those cost estimates and pro-rated the $23 million shown for facilities planning into categories similar to those used in the Needs Survey. The results are as follows:

Facilities Category		Million Dollars
I and II, Treatment		630
III	I/I analyses	5
IV A	New Collector Sewers	55
IV B	New Interceptors	170
V	Combined Sewer Overflows	240
VI	Stormwater	not included
	TOTAL	$1,100 million

A summary by category of local needs from the 1976 National Needs Surveys for the expanded MSD service area is shown below with costs as stated in the EMMA Recommended Plan listed for comparison.

1976 National Needs Survey costs for the entire Study Area are also shown together with preliminary MAPC results from the 208 Study for comparison.

Category	Million Dollars			
	For Expanded Area 53 Communities		For 109 Communities	For 92 Communities
	76 Survey	EMMA	76 Survey	MAPC
I	62.2	433.8	124.9	630.0
II	0	39.7	31.5	
III A	0.9	2.0	2.2	5.4
III B	45.0	0	45.9	0
IV A	109.9	0	367.8	54.8
IV B	54.4	109.9	143.0	170.0
Subtotal	271.4	585.4	715.3	860.2
V	198.2	270.0	198.2	240.0
VI	1,912.5	456.0	1,912.5	0
Total	2,382.1	1,311.4	2,826.0	1,100.2

As we indicated earlier, the 1976 Need Survey data did not include MDC costs for treatment, I/I correction and new interceptors.

If one were to accept the largest values for each category, the cost estimates for needs in the Study Area would be at at least as much as is shown below:

Category		Million dollars
I and II		630.0
III A		5.4
III B		45.9
IV A		367.8
IV B		170.0
	Subtotal	$1,219.1 million
V		270.0
VI		1,912.5
	Total	$3,401.6 million

See NOTE on page 3.80

H. SUMMARY OF CHAPTER 3

1. The EMMA Report is the result of an intensive interagency study of municipal wastewater facilities needs of 109 communities in Eastern Massachusetts. Particular emphasis was given to the 43 member-community area of the Metropolitan Sewerage District. Although the study is preliminary to facilities planning, many different approaches and candidate concepts were studied at the feasibility level. The various solutions were screened and viable alternatives were presented as a Recommended Plan of fifty-two projects. It should be pointed out that these projects do not include all the facilities needed to comply with water quality requirements and do not include projects to be carried out directly by local MSD member communities. Each project is to be separately implemented through the three steps of the Clean Water Grant process.

Step 1 work has been completed for one project however, primary sludge management facilities for the Deer and Nut Island Plants.

2. The EMMA Recommended Plan provides for expanding the MSD service area from 208 to 293 square miles. Fifty-one communities around Boston Harbor would be served, eight more than at present.* The remaining fifty-eight communities in the peripheral part of the Study Area are not included in the Recommended Plan.

3. None of the communities recommended to be incorporated into the expanded MSD system have existing sewerage systems. Therefore, no existing treatment plants would be abandoned by the proposed consolidation.

---

* (The eight communities have a projected year 2000 sewered population of 62,000 and average flow of 8.5 MGD.)

4. Under the Recommended Plan seven pump stations of an average age of 56 years would be replaced. All other existing facilities are planned to be rehabilitated and reused to the maximum extent possible. No useable facility is scheduled for abandonment in the Recommended Plan, unless it is very old, obsolete and considered to have exceeded its useful life.

5. The Recommended Plan for dry-weather flow management is to upgrade and expand existing facilities of the Deer Island and Nut Island systems. The service area tributaty to Nut Island would be reduced. New advanced waste treatment facilities would be added at satellite areas on the Middle Charles River and the Upper Neponset River. The average daily flow capacity of treatment works would be:

Plant	MGD
Secondary at Deer Island	400
Secondary at Nut Island	130
AWT at Middle Charles River	31
AWT at Upper Neponset River	25
Total	586

This capacity is proposed to serve 2,440,000 persons in the year 2000 and is equivalent to 240 gallons per person per day.*

Four separate projects are recommended as a basis of facilities planning for combined sewer overflow regulation during wet weather. They are shown at Dorchester Bay, the Charles River Basin, the Neponset River Estuary and at Boston Inner Harbor. It is indeterminate at this time whether they will meet requirements or be found cost-effective. We review this subject further in Chapter 5.

---

* (Includes commercial and industrial contributions and I/I allowances.)

6. Criteria for facilities in the Recommended Plan include projections that the Northern part of the Metropolitan Sewerage District will have a population of 1,460,000 persons in the year 2000. The average daily flow capacity of 400 MGD at Deer Island is equivalent to 274 gallons per capita per day including flows from non-residential sources.

Average daily Deer Island loadings for design year 2000 are estimated as follows:

Wastewater Stream	Biochemical Oxygen Demand Pounds per Day	Suspended Solids Pounds per Day
Influent	555,000	511,000
Primary Effluent	338,600	245,300
Secondary Effluent	83,250	76,650

There is uncertainty regarding the primary limit. The NPDES permit allows 474,000 pounds per day of BOD and 306,000 pounds per day of suspended solids. Anticipated primary effluent emission, which would become secondary influent loadings, are not given in the reported design criteria.

7. Criteria for facilities in the Recommended Plan include projections that the southern part of the Metropolitan Sewerage District will have a population of 979,900 persons in the year 2000. The combined average daily flow capacity of 186 MGD allowed at the three plants (Nut Island and two satellite plants) is equivalent to 190 gallons per capita per day including flows from non-residential sources.

Average daily loadings for design year 2000 for the combined Nut Island System are estimated as follows:

Wastewater Stream	Biochemical Oxygen Demand Pounds per Day	Suspended Solids Pounds per Day
Influent	300,400	365,900
Primary Effluent	209,000	181,000
Secondary Effluent	44,200	45,275

These loadings would be distributed at three sites with approximately seventy percent tributary to Nut Island, seventeen percent on the Middle Charles River and thirteen percent on the Upper Neponset River. The advanced waste treatment satellite plants are estimated to have the following emissions:

Parameter	Middle Charles River Plant	Upper Neponset River Plant	
BOD	1300	1050	pounds per day
SS	1300	1050	" " "
Ammonia Nitrogen	260	210	" " "
Phosphorous	260	210	" " "

8. Combined sewer overflows of one-year frequency and six-hour duration were predicted from the 38-square mile combined sewer area in five core communities. Most of the combined sewer overflows occur in the Northern part of the MSD tributary to Deer Island. Preliminary emission rates of the annual event for facilities planning purposes were reported as follows:

Parameter	Emission	Units
Peak flow	8,400	MGD
BOD	75,100	Pounds
SS	795,480	Pounds
Coliform	10^3 to 10^8	MPN per 100 ml

Lesser flows would occur on an average at seven-day intervals throughout the year.

Effluent limitation from combined sewer overflow regulation facilities have not been established, and data are unavailable as to levels of toxic materials in overflow discharges. Facilities similar to those at the existing MDC Cottage Farm Detention and Chlorination Station in Cambridge have been used as a basis of preliminary cost estimates in the EMMA Report for needed combined sewer overflow regulation projects. That may prove to be an inadequate amount for the purpose.

9. Estimated costs of the fifty-two projects of the Recommended Plan total $855.4 million on the basis of an ENR Index of 2200 representing January 1975 prices. Facilities in the Plan can be summarized into five groups, as follows:

Service Area	$ Million
Deer Island	302.6
Nut Island	147.7
Middle Charles River	79.0
Upper Neponset River	56.1
Combined Sewer Overflow Projects	270.0
Total	$855.4 million

10. The estimated cost, as reported in the EMMA Report for all facilities contained in the EMMA Recommended Plan, when categorized pursuant to the nationwide Needs Surveys would be as follows:

Facilities Category		$ Million
I	Secondary Treatment	433.8
II	More Stringent Treatment	39.7
III A	Infiltration/Inflow Correction	2.0
III B	Major Sewer System Rehabilitation	0
IV A	New Collectors	0
IV B	New Interceptors	109.9
V	Correction of Combined Sewer Overflows	270.0
VI	Stormwater Treatment and/or Control	0
	Total	$855.4 million

11. Kennedy Engineers has performed a present-worth analysis of the facilities in the Recommended Plan in accordance with EPA guidelines and at the same price level as in the EMMA Report. The estimated present-worth of the combined capital and operation and maintenance costs is $603 million.

The present worth of the combined capital and operation and maintenance computed in accordance with EPA guidelines is less than the total capital cost alone because:

a. The planning period is only 20-years compared to the useful life of facilities of 30 or 50 years, and depreciated capital costs remaining at the end of the planning period must be deducted as "salvage."

b. Some major capital expenditures are scheduled late in the planning period.

c. Operation and maintenance costs are included only for short periods between completion of construction and the end of the planning period, and

d. Inflation is disregarded.

12. The apparent real dollar cost of the Recommended Plan has been estimated based on an inflation factor of 8.6 percent per year. At that rate of inflation, the estimated price for construction of the recommended projects would be $1,753 million. The present worth of that inflated price and the operation and maintenance cost is $1,546 million when brought back to 1975 cost levels.

13. Data from the 1976 National Needs Survey updates indicate the costs for needed publicly-owned treatment facilities in the Study Area, based on 1990 population are:

See NOTE on page 3.80

Category		$ Million
I	Secondary Treatment	124.9
II	More Stringent Treatment	31.5
III A	Infiltration/Inflow Correction	2.2
III B	Sewer System Rehabilitation	45.9
IV A	New Collector Sewers	367.8
IV B	New Interceptor Sewers	143.0
	Subtotal	715.3
V	Combined Sewer Overflows	198.2
VI	Stormwater Control	1,912.5
	Total	$2,826.0

Estimates from the same source for the Metropolitan Sewerage District and for all communities in the MSD expanded service area are $2,382.1 million.

Estimates for peripheral area communities and regional service agencies other than the MSD are $443.9 million.

The 1976 Needs Survey cost estimates for the expanded MSD service area are $112 per capita for categories I through V and $1,158 per capita for all categories. By comparison, cost estimates in the 1974 Needs Survey for Massachusetts were $420 per capita for categories I through V and $863 per capita for all categories.

One reason that the 1976 Need Survey cost estimate updates are low in categories I through IV is that except for sludge management facilities, no needed MDC projects appeared in the data provided to us.

14. The Contruction staging program is a key element of the Recommended Plan. It establishes project priorities and the timetable of grant process

through the year 2000. Through the NPDES Permit system and the accompanying Enforcement Schedule Compliance Letter, the Commonwealth of Massachusetts DWPC and the EPA have influenced the priorities and timing of project implementation. The most significant influence of EPA resulted in moving the construction date for secondary treatment facilities about fifteen years sooner on the schedule.

15. The NPDES Permit jointly issued by the EPA and the Commonwealth of Massachusetts DWPC to the Commonwealth of Massachusetts Metropolitan District Commission authorizes the discharges of wastewater in the amounts and general location as proposed in the EMMA Recommended Plan.

16. Region I of the EPA has approved the EMMA Report as the Water Quality Management Plan for Boston Harbor pursuant to Section 303(e) of Public Law 92-500.

17. The number one priority project of the EMMA Recommended Plan is sludge management facilities for the existing Deer Island and Nut Island primary treatment plants. Step 1 planning was completed in 1973 but the project is stalled in the Step 2 design phase in order to satisfy the requirements of the National Environmental Policy Act.

18. Preparation of the Environmental Impact Statement on the major EMMA Study Projects has begun under the direction of the EPA. The scope consists of matters relating to the siting of new Deer Island and Nut Island plants, questions about sludge management facilities and the need for satellite advanced waste treatment plants.

There are unanswered questions about the proposed projects which are not included in the scope of the EIS now being prepared. Items which we consider of technical significance are:

> The issue of how large the Metropolitan Sewerage District should expand,
>
> The unit wastewater criteria for facility design, including I/I allowances, and
>
> The issue of how combined sewer overflows should be treated and where they should be discharged.

19. Over ninety percent of the MSD member communities have deficiencies such as raw sewage discharges, combined sewer overflows, excessive inflow and infiltration, overflows and bypasses of untreated sewage, and areas now unsewered projected to require sewers in the future. The EMMA Recommended Plan does not provide facilities to solve all these local problems in the member communities.

It is clear that the facilities proposed in the Recommended Plan of the EMMA Report are not planned to eliminate all water quality problems in the Study Area.

20. We have reviewed the need for wastewater facilities as reported by the Metropolitan Area Planning Council 208 project, the EMMA Report, and the local results of the nationwide 1976 Needs Survey update. Preliminary data from these sources, together with other local engineering reports and our own observations indicate that grant eligible costs of needed municiapl wastewater facilities easily exceeds 3.4 billion dollars at present cost levels. That would be about $1400 per capita.

REFERENCES

3.1 Metcalf & Eddy, Inc., Et al/MDC
"Wastewater Engineering and Management Plan for Boston Harbor - Eastern Massachusetts Metropolitan Area - EMMA Study"
Summary Report, March 1976
Main Report, March 11, 1976
Twenty-three Technical Data Volumes dated October 1975 - (For full listing see references in Chapter 1).

3.2 Martin Weiss, Director of Environmental Planning, MDC, and
Jekabs P. Vittands, Vice-President of Metcalf & Eddy, Inc., Boston
"Wastewater Engineer and Management Plan for Boston Harbor"
October 1976.

3.3 Havens and Emerson/MDC
"A Plan for Sludge Management"
August 30, 1973.

3.4 EcolSciences, Inc.,/EPA Region I
"Draft EIS, Proposed Sludge Management Plan, MDC, Boston Massachusetts,"
Volumes I and II
Feburary 13, 1976.

3.5 EPA Region I
Scope of Work for EIS on Major MDC Projects, being a portion of a Request for Proposal issued 1976.

3.6 Engineering News-Record
"ENR Construction Cost Index"
McGraw-Hill, New York, N.Y.

3.7 U.S. EPA, Office of Water Program Operations,
Municipal Construction Division
"Cost Estimates for Construction of Publicly-Owned Wastewater Treatment Facilities - 1974 'Needs' Survey"
Final Report to the Congress February 10, 1975
Revised May 6, 1975.

3.8 Metropolitan District Commission
"Information Packet for May-June 1975 Public Meetings, EMMA Study"
May 1975.

3.9 EPA, Region 1 and Massachusetts DWPC
Joint Notice of a Public Hearing Relative to Issuance of NPDES Permit to MDC, with Draft Permit
January 9, 1976.

3.10 Ibid.
Discharge Permit MA 0102351 Issued to MDC
August 12, 1976
Effective 45 days thereafter
Expires May 1, 1981.

3.11 EPA
"Water Pollution Control Construction Grants for Waste Treatment Works"
FR Vol. 39, No. 39, Feburary 11, 1974
40 CFR Part 35
Appendix A, Revised August 1976.

3.12 Telephone communication between Michael K. Mullis, Kennedy Engineers, and Carroll Leslie Bastian, National Science Foundation,
December 20, 1976.

3.13 Camp, Dresser & McKee, Inc./City of Boston
"1975 Supplement to 1967 Report on Improvements to the Boston Main Drainage System (Facilities Plan)"
Draft November 1975
Revised March 30, 1976.

3.14 Camp, Dresser & McKee, Inc./City of Somerville
"Improvements to the Sewer System"
April 30, 1974.

3.15 MAPC
Interim Output of 208 Study
Preliminary data May 1976.

3.16 Ibid.
"Clean Water? Our Common Concern"
208 Project Brochure, September 1976.

3.17 U.S. EPA
"Clean Water, Report to Congress - 1974"
June 1974.

3.18 U.S. EPA
"Cost Estimates for Construction of Publically-Owned Wastewater Treatment Facilities, 1974 'Needs' Survey"
Final Report to the Congress February 10, 1975
Revised May 6, 1975.

3.19 Dames and Moore/U.S. EPA
"Operations Manual for 1976 Update of Needs for Publically Owned Wastewater Facilities"
(Categories I-IV)
April 1976.

3.20 Jordan, Jones & Goulding, Inc. and Black Crow & Eidsness, Inc./U.S. EPA
Data for Boston from 1976 Survey of Needs (Categories V and VI)
Contract 68-01-1984, Phillip H. Graham Telephone Conversation.

3.21 Dames & Moore
Computer Printouts of the 1976 Needs Survey for Municipalities in the NSF Study Area, Categories I-IV
January 24, 1977.

3.22 Preliminary Results of 1976 Needs Survey for Boston Area, Categories V and VI.

NOTE: After this chapter was written, we received a copy of the 1978 Needs Survey forms for Deer Island, Nut Island, Middle Charles and Neponset River wastewater treatment plants, together with a factor to adjust 1978 costs to the 1976 price level.* The adjusted costs of the 1978 data would add to the needs of the MDC $353.8 million in Category I, $77.8 million in Category II, and $99.9 million in Category IVB, which total $531.5 million.

Revised needs are as follows:

Category		$ Million
I		416.0
II		77.8
III		45.9
IVA		109.9
IVB		153.3
	Subtotal	802.9
V		198.2
VI		1,912.5
	Total	2,913.6

The total is equivalent to $1,194 per capita.

*Additional data were furnished February 22, 1978 by US EPA, Washington, D.C.

On October 17, 1978, EPA Region I acknowledged that the 1976 Needs Survey figures were incorrect but still cannot correlate the revised figures.

CONTENTS

Chapter 4

RAW SEWAGE DISCHARGES

Section	Title	Page
A.	RAW SEWAGE DISCHARGES	4.2
	1. Scope	4.2
	2. Effects of Raw Sewage Discharges	4.2
B.	EXTENT OF THE PROBLEM	4.6
	1. Continuous Raw Sewage Discharges	4.18
	2. Intermittent Discharges	4.20
	3. Other Sources of Untreated Discharges	4.23
C.	CORRECTION OF RAW SEWAGE DISCHARGES	4.26
	1. Requirements	4.26
	2. Elimination of Continuous Raw Discharges	4.27
	3. Correction of Intermittent Flows	4.32
D.	SUMMARY OF CHAPTER 4	4.35
	REFERENCES	4.38
	FIGURE 4-1 Raw Sewage Discharges	4.16
	TABLE 4-1 Flows and Loadings	4.17

Chapter 4

RAW SEWAGE DISCHARGES

This chapter will consider the problem of raw (untreated) sewage discharges into the receiving waters of the Study Area. The emphasis in this section will be on municipal wastewaters, that is, on sanitary wastes originating from the sewered parts of cities and towns of eastern Massachusetts. Industrial and institutional wastes will not be considered, although a large quantity of untreated waste may be discharged by these facilities. Combined sewer overflows will be covered in Chapter 5.

The first part of the chapter will define a raw sewage discharge, and will discuss the effects on the environment. Following this, the extent of the problem in the Study Area will be examined. The last part will explain what measures are presently planned to abate the discharges.

A. RAW SEWAGE DISCHARGES

1. SCOPE

At briefings held in May 1976 for members of the Phase I Study Team, we were advised that there are many raw sewage discharges in the Study Area. For purposes of this study we are defining raw sewage as that which receives less than primary treatment, and is from separate sanitary sewers (not from combined sewer overflows).

Raw sewage discharges are continuous when no treatment is provided, and are intermittent by-passes or overflows when treatment is provided part of the time or for part of the flow.

Guidelines have been produced by EPA Region 1 to assist permittees to report discharges due to by-passes and overflows. In that undated document, the following definitions appear:

> "By-pass - A bypass is an arrangement of pipes, conduits, gates or valves where all or a portion of the flow is diverted and results in a discharge."
>
> "Overflows - An overflow occurs when the volume of water exceeds the capacity of a transport system causing extra water to be spilled or forced out of the system into a waterway."

2. EFFECTS OF RAW SEWAGE DISCHARGES

We are able to verify that many communities in the Study Area are presently sewered (partly or completely), yet do not operate sewage treatment plants to stabilize some or all of the wastewater before discharging to receiving waters. Some of these municipalities belong to regional sewerage agencies which maintain treatment facilities for handling the wastes from the member communities. Other cities and towns provide no treatment at all for the wastes, and simply discharge the sewage without treatment into the receiving waters. These are the situations that we will examine at this time. We will also consider the untreated discharges from by-passes that may occur at a pumping plant or a treatment facility due to power or mechanical failures. Finally we will comment on those by-passes that may occur en-route to a treatment facility or to a regional sewage district's interceptor, when the hydraulic capacity of the sewer is exceeded.

It should be kept in mind that the numerous overflows of wastewater from combined stormwater/sanitary sewers will not be covered in this chapter. These discharges, although untreated, are due to the exceeding of the hydraulic capacity of the sewers or treatment plant during a rainstorm, and are intermittent.

The effects of discharging untreated sewage into a body of water can be grouped into three categories: health, ecological, and aesthetics. The health hazard stems from the fact that untreated sewage contains a number of pathogenic organisms in the form of bacteria and viruses. A risk of the spreading of a water-borne disease (typhoid, cholera, infectious hepatitis, salmonella, etc.) exists when a body of water contaminated by untreated or inadequately treated sewage is used for recreation, water supply, or as a source of food.

Such hazards exist in the case Study Area. The potential for water supply contamination is clearly evident in that the town of Billerica uses the Concord River as a potable water source, downstream of several wastewater discharges. Many communities use water from wells adjacent to Study Area rivers. Frequent sewage contamination of shellfish areas has caused the requirement that shellfish taken from certain areas of the harbor be cleansed and disinfected prior to sale. In addition, shellfish may concentrate toxic substances contained in sewage discharges.

The ecological effect of discharging untreated sewage into water is the upset of the biological balance through nutrient induced aquatic blooms. Damage is also possible due to the toxic elements that may be discharged with the effluent. Also to be considered, is the high oxygen utilization rate (biochemical oxygen demand, BOD) that is exerted when an unstabilized organic waste is discharged to a body of water. If the water cannot tolerate the waste, an oxygen depletion may occur, having serious effects on aquatic life.

Aesthetics ties in very closely with the need to eliminate raw discharges due to the unappealing appearance of a lake, river or ocean that has floating material (fecal solids, scum, greaseballs), color, foam, or an odor associated with it. The oxygen depletion of sewage discharges and sludge bank accumulations can cause severe hydrogen-sulfide odor nuisances. Sewage constituents can also cause taste and odor problems where water is used for potable supply.

It is obvious that untreated sewage discharges produce an undesirable effect on receiving waters. Untreated sanitary discharges are prohibited after July 1, 1977. After that date all such discharges to navigable waters are required by law to have a minimum of secondary (biological) treatment. This has been dictated by the Federal Water Pollution Control Act Amendments of 1972.

B. EXTENT OF THE PROBLEM

An assessment of the existing raw sewage problem is not found for the Study Area. Various sources of data are available, however, which have been utilized to determine its apparent extent.

We have analyzed the data from the 1976 Needs Survey, reference 4.1, in order to aid in identifying sewered municipalities with insufficient treatment capacity or treatment level.

For this purpose, we are assuming that a community listed as having treatment needs and negligible or no need for collecting sewers is discharging wastewater not meeting required effluent limitations. The following communities in that category could be discharging an unknown quality of wastewater less than secondary treatment plant effluent.

Community	Category I Needs, $ Million
Cohasset	1.9
Swampscott	2.5
Gloucester	10.2
Marshfield	3.1
Millis	0.5
Sudbury	2.2
Total	$20.4 million

In addition, the Lynn Regional System is shown with secondary treatment needs of $32.1 million. Sewage treatment needs of the MDC for the MSD system was not found in the 1976 Needs Survey.

The following eight peripheral area communities are listed as needing more stringent treatment than secondary:

Community	Category II Needs $ Million
Acton	7.8
Concord	4.8
Rockland	4.6
Scituate	2.9
Hudson	1.4
Milford	4.5
Essex	0.8
Westborough	4.7
Total	$31.5 million

New regional tertiary plants proposed by the EMMA Report on the Middle Charles River and on the Upper Neponset River were also not found in the 1976 Needs Survey.

Of those communities listed above, the ones which are believed to have no treatment plant and therefore could be discharging raw sewage according to this deductive analysis are:

Sudbury,
Acton, and
Essex.

This list does not agree with information in the EMMA Main Report, reference 4.2, which shows that there were "0" sewered acres and "0" sewered population for those communities in 1970.

On the other hand, the data in the Needs Survey does not specifically indicate when part of a community may be discharging raw sewage or when there are by-passes or overflows of raw sewage.

The Charles River Basin Plan, reference 4.3, contains information on significant discharges in that Basin. The only municipal system shown with no treatment is the Broad Street Sewer in Medway which continuously discharges untreated sanitary wastes into Great Black Swamp.

The same reference states the following on intermittent untreated discharges of municipal sewage:

> "In Milford, Waltham, and communities of the Middle (Charles River) Watershed served by the Wellesley - Framingham interceptor system of the MDC, untreated municipal sewage occasionally, or perhaps frequently, enters the Charles and its tributaries from sewer overflow structures or, in some cases, by-pass structures at sewage pump stations."

None of those communities have combined sewer systems according to the MDC Annual Reports. The MDC reports that the overflows are due to excessive infiltration/inflow problems of member communities according to reference 4.4, and has enforced bans on the extension of new sewer service in Natick and Framingham.

Millis is reported to have by-pass facilities at its treatment plant but no use of them is reported.

The Joint Task Force Report on Major Manned MDC Facilities, reference 4.5, reports in Appendix B that overflows occur in Hingham both from the MDC system and from the City system. The Report states the MDC pump station has "two by-passes to Back River which are used due to problems in the City System." It is also reported that:

> "When the town of Hingham sends too much flow to the MDC's Hingham Pump Station, MDC by-passes to Back River and notifies Environmental Health

> who may close the clam flats. Occasionally , Hingham sends no flow at all to MDC. This happened in February March and September of 1975 and on the occasion of our visit (in 1976). It is assumed that the City of Hingham is bypassing raw (sewage) to Broad Cove during these periods."

Since Hingham is a member of MDC, it has no discharge permit and therefore does not report direct sewage discharges. Undoubtedly there are other communities tributary to district facilities that also do not report direct discharges. Few existing pump stations meet present EPA requirements for new pump stations of dual power source and standby facilities. Upon power outages or loss of capacity, older pump stations are often forced to by-pass raw sewage as a consequence.

Other sources of data used in this section are:

EMMA Study Technical Volumes 2, 4 and 13C,
(appended to reference 4.2.)

EPA's NPDES Non-compliance
Quarterly Report for
May, June and July 1976,
reference 4.6,

North Coastal Basin Plan,
July 1975, reference 4.7,

Preliminary interim output data
of MAPC, 208 Project,
May 1976, reference 4.8,

NPDES Permits, reference 4.9, and

MDC Annual Reports of Sewerage Division,
reference 4.10.

Many of the NPDES permits jointly issued by the DWPC and the EPA contain provisions in whole or in part on the subject of raw sewage. Several examples are cited here. The examples show that the permittees have been authorized to continue the discharges only until a certain date; other provisions of the permits require, in some cases, implementation of a program for treatment, consolidation or other actions to correct the discharges. In most cases, however, the permits expire before raw sewage discharges are terminated. The requirements of the permits as given under the section thereof entitled "Effluent Limits" are as follows:

a. City of Gloucester was issued a permit December 23, 1974 which states "Until June 1, 1977, the permittee is authorized to discharge untreated wastewater to Gloucester Harbor from Discharge Serial number 001."

That discharge is noted as the Main City outfall with an average flow of 2.51 mgd and a discharge frequency of "continuous."

No effluent limits are given for the discharge after that date, presumably because the permit expires on the same date.

b. Town of Hull was issued a permit July 16, 1976 which states, "Until July 1, 1977, the permittee is authorized to discharge untreated wastewater from:

Discharge serial no. 001 to Hull Gut,
Discharge serial nos. 002, 003, and 009 through 012 to the Atlantic Ocean, and
Discharge serial numbers 004 through 008 to the Weir River."

The implementation schedule requires the town to: "Commence construction of the approved secondary WWTF, Pump Station's, Force mains and sewers by March 16, 1976" (said date being four months prior to the date of issuance of the permit).

Secondary treatment level of discharge limitations are given for a new discharge location effective March 16, 1978.

The expiration date of the permit is July 1, 1977.

c. City of Lynn was issued a permit December 31, 1974 which states:

"Until June 30, 1977, the permittee is authorized to discharge screened wastewater from Discharge Serial Number 001 to Lynn Harbor."

The attachment to the permit states that Discharge Number 001 is the Main outfall with a continuous discharge of 25.3 mgd.

The permit requires the City to "commence construction of approved treatment facilities by June 30, 1977."

No date is given for the facilities to be operational.

The permit expires June 30, 1977.

d. Town of Rockport was issued a permit April 30, 1974, stating "until September 30, 1976, the permittee is authorized to discharge untreated wastewater from the existing discharge at North and Doyle's Cove Road (Bearskin Neck) to Rockport Harbor." and after that date "the permittee is authorized to discharge from Rockport Wastewater Treatment Facility and effluent to Rockport Harbor whose characteristics shall not exceed..." secondary treatment levels.

We have been advised that the required facilities are now in operation.

e. City of Salem was issued a permit July 3, 1974 which states, "Until June 1, 1977, the permittee is authorized to discharge untreated wastewater overflow to the North River (Beverly Harbor) from Discharge Serial Number 002, as described on Attachment A and subject to General Condition 19. This permit is conditioned upon the permittee remaining tied-in to the South Essex Sewerage District sewerage system for the duration of the permit." General Condition 19 states in part, "The diversion or by-pass of any discharge from waste treatment facilities utilized by the permittee to maintain compliance with the terms and conditions of this permit is prohibited except (1) where unavoidable to prevent loss of life or severe property damage, or (2) where excessive storm water or runoff would damage any facilities necessary for compliance with the terms and conditions of this permit."

The expiration date is June 1, 1977.

f. South Essex Sewerage District applied for a permit on August 30, 1973. A permit marked "Revised Draft Copy Jan. 3, 1975" but unsigned was made available for review. That permit, if issued, would require the following: "Until March 31, 1976, the permittee is authorized to discharge screened wastewater from Discharge Serial Number 0001 to Salem Harbor." The flow is given as 41.0 mgd. Effluent approximating the primary level of treatment would be required effective November 30, 1976 had the permit been issued.

Scheduled expiration date was shown as June 30, 1977.

The same draft permit included the following additional provisions:

"Until June 30, 1977, the permittee is authorized to discharge untreated wastewater bypass flows from Discharge Serial Number 006 to the North River Canal and from Discharge Serial Number 007 to Salem Harbor" and

"Until March 31, 1976, the permittee is authorized to discharge untreated wastewater bypass flows from Discharge Serial Number 008 to Salem Harbor. The discharge shall then be terminated.

Discharges 006, 007, and 008 are noted as intermittent. Specific requirements for discharges 006 and 007 were not included.

g. Metropolitan District Commission was issued a permit August 12, 1976 with an expiration date of May 1, 1981 which is modified by the Enforcement Compliance Schedule Letter. These documents permit certain by-passes of treatment units, discharges at other than the normal outfalls, and discharges from overflow structures in the system as follows:

(1) Deer Island System. Three relief outfalls (003, 004, and 005) are allowed to be used only when the flow exceeds 400 mgd until October 1, 1984. Use of diversions and by-passes are prohibited after July 1, 1977 except under certain conditions.

(2) Nut Island System. Until October 1, 1984, the permittee is authorized to discharge from Discharge Serial No. 104 (called an "emergency relief") of the Nut Island Facility into Hingham Bay during periods when the influent flow rate exceeds 250 mgd and/or during abnormally high tides. All flows are to receive screening, disinfection, and the influent is to be pre-chlorinated. The discharge is not required to be montoried. The permittee is also required to notify the Quincy Commissioner of Public Health of by-passes occurring from May

through September. Discharge Serial No. 106 is the overflow from the MDC Weymouth (Hingham) Pump Station which goes to the Weymouth Back River. The permit authorizes this discharge to be untreated until July 1, 1977; after that date it must receive "the best practicable control technology currently available, as defined by the Regional Administrator."

h. City of Boston was issued a permit April 2, 1975 authorizing 125 discharges until June 30, 1977. Discharge Serial Number 125 is from the Moon Island facility. That discharge is required to be chlorinated and released only during ebb tides. The permittee is also required to notify the Quincy Commissioner of Public Health when a discharge occurs.

The permit also states: "No new wastewater flows will be allowed to connect into the permittee's sewerage system unless prior written permission has been obtained from the Massachusetts DWPC and the MDC."

Three of Boston's discharges are listed as "untreated wastewater: No. 039, a 60 inch sewer on Amory Street extended, in Brighton, to the Charles River; No. 098, a 30 inch sewer at Malibu Beach Cove at Denny Street extended, in Dorchester, going to Dorchester Bay; and No. 114, a 24 inch sewer at Warren Avenue extended in Dorchester, going to the Neponset River.

Most raw sewage discharges in Boston are combined sewer overflows which is the subject of Chapter 5.

The permits are useful as a partial inventory of discharges and bypasses as sc designated by the permittees in their applications. They also serve to indicate the influence the EPA Enforcement Division is exerting to correct them.

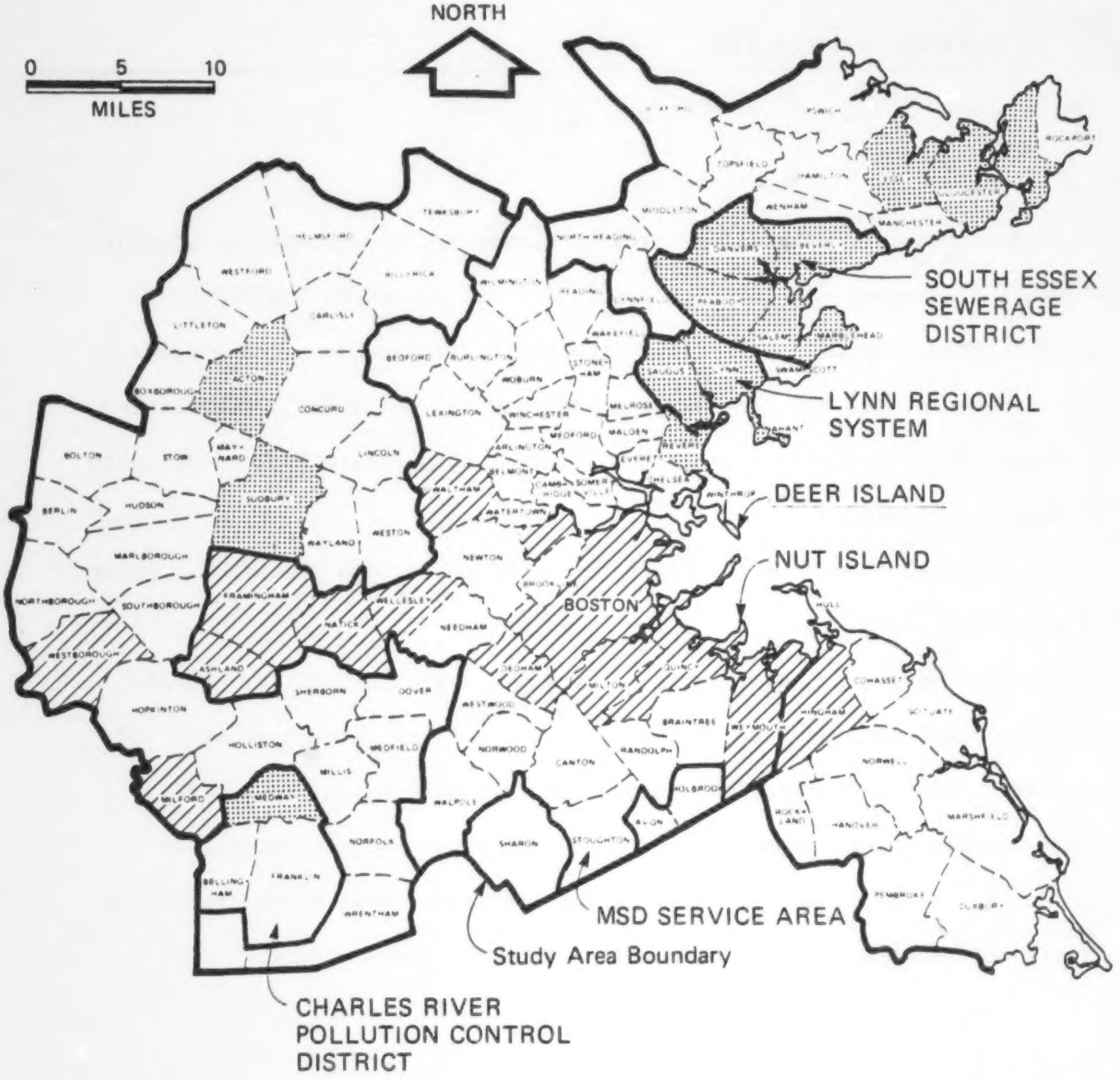
Communities and regional agencies with apparent or reported continuous raw sewage discharges are shown on Figure 4-1 and listed on Table 4-1. These discharges are not necessarily from the entire agency. Those agencies may also have intermittent raw sewage overflows and by-passes. Communities and regional agencies with only intermittent discharges are shown also, with a different designation.

On Table 4-1 flow data contained in the NPDES permits are noted. Other flow data were estimated.

The fifty-seventh Annual Report of the MDC indicates that of the 43 member communities, only one, Bedford, is one-hundred percent sewered and one-hundred percent of the population is contributing sewage to the MSD.* For all members, there is an average of 90.83 percent of the population contributing sewage from 51.44 percent of the area. Some of the remaining population is sewered and not connected to the MDC interceptors.

---

* (It is noted that this information does not agree with MAPC information reported in the previous chapter. There are sewers in MDC member communities that discharge elsewhere than to MDC interceptors according to NPDES permits and other referenced data.)


NORTH
0
5
10
MILES
SOUTH ESSEX SEWERAGE DISTRICT
LYNN REGIONAL SYSTEM
DEER ISLAND
NUT ISLAND
BOSTON
MSD SERVICE AREA
Study Area Boundary
CHARLES RIVER POLLUTION CONTROL DISTRICT
TOPSFIELD
IPSWICH
HAMILTON
ROCKPORT
WENHAM
MANCHESTER
MIDDLETON
NORTH READING
DANVERS
PEABODY
SALEM
MARBLEHEAD
SWAMPSCOTT
LYNN
SAUGUS
WAKEFIELD
READING
STONEHAM
WILMINGTON
TEWKSBURY
CHELMSFORD
BILLERICA
WESTFORD
CARLISLE
LITTLETON
BOXBOROUGH
ACTON
CONCORD
BEDFORD
BURLINGTON
WOBURN
LEXINGTON
WINCHESTER
MELROSE
MEDFORD
MALDEN
EVERETT
REVERE
CHELSEA
WINTHROP
ARLINGTON
BELMONT
CAMBRIDGE
SOMERVILLE
LINCOLN
MAYNARD
STOW
BOLTON
BERLIN
HUDSON
SUDBURY
WAYLAND
WESTON
WALTHAM
WATERTOWN
NEWTON
BROOKLINE
MARLBOROUGH
NORTHBOROUGH
SOUTHBOROUGH
WESTBOROUGH
FRAMINGHAM
NATICK
WELLESLEY
NEEDHAM
ASHLAND
HOPKINTON
SHERBORN
DOVER
DEDHAM
WESTWOOD
MILTON
QUINCY
HULL
COHASSET
SCITUATE
HINGHAM
WEYMOUTH
BRAINTREE
RANDOLPH
HOLBROOK
NORWOOD
CANTON
HOLLISTON
MEDFIELD
MILLIS
MILFORD
MEDWAY
NORFOLK
WALPOLE
SHARON
STOUGHTON
AVON
ROCKLAND
HANOVER
NORWELL
MARSHFIELD
PEMBROKE
DUXBURY
BELLINGHAM
FRANKLIN
WRENTHAM

LEGEND

░ Places with continuous raw sewage discharges reported

▨ Places with intermittent raw sewage discharges reported.

Basemap: EMMA Report

NSF Boston Case Study, Phase II Evaluation

RAW SEWAGE DISCHARGES

Kennedy Engineers, Inc. 1977

Figure **4·1**

TABLE 4-1

CONTINUOUS RAW SEWAGE DISCHARGES AND POLLUTIONAL LOADINGS

BASIN	MUNICIPALITY	REPORTED OR PERMITTED FLOW, AVERAGE MGD	ESTIMATED FLOW, MGD AVERAGE	ESTIMATED FLOW, MGD PEAK	BOD AND S.S. EMISSIONS (1)(lbs/day) AVERAGE	BOD AND S.S. EMISSIONS (1)(lbs/day) PEAK
North Coastal	Gloucester	-	3.93	10.8	6,600	18,000
	Lynn (2)	25.3	-	43.6	42,200	72,700
	Marblehead (3)	2.5	-	10.8	4,200	18,000
	Nahant (2)	-	0.70	3.1	1,200	5,100
	Saugus (2)	-	2.11	6.4	3,500	10,700
	SESD	26.0	-	46.6	43,000	78,200
Charles	Medway	-	0.11	0.4	180	720
Boston Harbor	Boston (4)	-	0.01	0.03	20	50
	Revere (4)	-	0.40	1.0	700	1,750
Weymouth	Hull	-	0.55	2.3	900	3,800
	Totals	53.8	7.8	125.0	102,500	209,000

Total average daily flow 61.6

(1) Emissions are based on 200 mg/l of BOD and SS for domestic sewage.
(2) Member Lynn Regional System
(3) Member SESD
(4) Member MDC

1. CONTINUOUS RAW SEWAGE DISCHARGES

At present there appear to be at least ten cities, towns and regional agencies in the Study Area that discharge raw sewage continuously into receiving waters. While some of the discharges have been measured, the others can only be estimated. The EMMA Study, in Technical Volume 2, has quantified the dry-weather sewage flows from all the communities in the Study Area by using information on population, industrial activity, water consumption, type and age of sewers, and extraneous flow.

The quantities shown in Table 4-1 that could not be obtained directly include the flows of untreated discharges from those communities that are served in part by a sewage treatment facility. This includes the City of Boston which is authorized to continuously discharge raw sewage from 3 points. The NPDES permit for the City of Boston does not limit the flows from these points, which discharge to the Charles River, Dorchester Bay, and the Neponset River. The untreated flow from Boston was computed by subtracting the flow that is accepted by MDC facilities, reference 4.10, from the total flow originating from the city as reported in the EMMA Study, Technical Volume 2, reference 4.2.

Also shown in Table 4-1 are the estimated pollutional loadings from the municipalities that presently discharge raw sewage. As monitoring is not required, no values could be assigned to the strength of the sewage. We assumed a value of 200 mg/1 for both the five-day biochemical oxygen demand (BOD) and suspended solids (S.S.) concentration of the discharges.

The total is an average daily flow of 61.6 mgd of raw sewage, which is estimated to have a loading of 102,500 pounds of BOD and suspended solids per day. At peak flows of 125 mgd, the pollutional loading is estimated to be 209,000 lbs/day of BOD_5 and S.S. These values do not agree with the MAPC, which reports an average flow of 150 mgd of raw sewage discharged within the 208 Study Area to ocean waters. This leads to the belief that the MAPC included combined sewer overflows in its totals.

The effect of these loadings on the receiving waters cannot be determined without an extensive water quality analysis. It is noted that the major discharges occur in the North Coastal Drainage Basin. However, even though there is a possibility of large dilution effects, the effect of the floatable materials on the coastal beaches and contamination of shellfish beds is undesirable.

The MAPC has advised informally that preliminary data indicate 150 mgd raw sewage is discharged in the 208 project Study Area. Other communities indicated as having raw sewage problems include Ashland, Milford, Milton, Quincy, Westborough and Weymouth.

The City of Revere is a special case of continuous raw sewage discharge. It is a member of MSD and a majority of it's sewage is conveyed into the MSD system. It is noted as having some combined sewers and is reported to have combined sewer overflows. In addition there are two areas of the City that are sewered and which discharge untreated sewage. The City of Revere has been issued its own NPDES permit, No. MA0102024. Thd MSD annual report states that 66 percent of the area and 96 percent of the population of Revere is contributing sewage to MSD. According to the EPA, the Beachmont and Point of Pines areas of Revere on the coast north of Winthrop continue to discharge raw sewage into Broad Sound near Revere Beaches in violation of the conditions of the NPDES permit issued to the City. The EPA also reports that the matter has been referred to the Attorney General, a consent decree was issued, and the dates for compliance were extended. It is noted that Revere has received a Step 1 planning grant but does not appear on the priority list for design or construction assistance.

It is to be pointed out that Table 4-1 is not believed to be complete. A survey of the available documents produced no information about several of the drainage basins, and little information about others. Thus, more continuous discharges may exist than are indicated in the Table. On the other hand, some reported raw sewage discharges may be receiving treatment by the time this Report is published.

2 MUNICIPALITIES INTERMITTENTLY DISCHARGING UNTREATED WASTEWATER

Intermittent discharges of raw sewage may occur in a community with separate sanitary sewers under several circumstances. One cause would be an inability to convey the sewage through a pump station or a treatment facility due to a power or mechanical failure. In this case, the wastewater may bypass the treatment facility and be directly discharged through a bypass structure or it may back up from the pumping facilities, and overflow from points in the sewer.

Nearly every sewage treatment facility is constructed with bypassing capability in the event of such a power or mechanical failure. Thus any of the existing plants listed in Chapter 1 may occasionally release untreated sewage.

An interesting situation exists, in this regard, with the MDC facilities in the Boston Harbor region. Should the hydraulic capacity of the pumping facilities at the Deer Island treatment plant be exceeded, part of the flow is diverted. Excess flow at the Columbus Park Headworks is diverted to the Calf Pasture pump station and discharged into the Harbor at Moon Island and may also overflow at other points in the system. The City of Boston reports that these by-passes are caused by inadequate pumping capacity in the MDC system. The Metropolitan District Commission claims that responsibility for by-passing is caused by excessive flows coming from the City. In either case, discharges from Moon Island still occur periodically, reportedly even in dry weather, although records of the volume and number of discharges are not available. Prior to a discharge at Moon, overflows are said to occur along the route between Columbus Park and Calf Pasture also.

A similar situation exists at the Ward Street Headworks. Under the same circumstances, the Ward Street Headworks may create a backup of a portion of the flow to the Cottage Farm Combined Sewer Chlorination and Detention Station. Although minimal treatment occurs at Cottage Farm, numerous untreated overflows to the Charles River Basin may occur before the flow reaches Cottage Farm.

The Chelsea Creek Headworks, when throttled due to inadequate pumping capacity may backup causing a diversion to the Winthrop Interceptor leading to the Winthrop Headworks at Deer Island. However, because the capacity of the North Metro Sewer and the Winthrop Terminal Pumps is much more than the 7 mgd for which it was used in FT 75-76 the facilities could be managed in such a way as to convey considerably more flow from East Boston to Deer Island and reduce raw sewage discharges.

An important aspect of these Boston Harbor discharges is that they frequently occur because of the throttling of gates at the headworks. When these discharges occur, not even minimal screening or degritting is performed and floatables are discharged with the overflows to the receiving water.

The MDC treatment facility at Nut Island has reported by-pass of raw sewage to the Harbor for one period this past year due to a lack of pumping ability. This resulted from a loss of digester gas which is the primary source of pumping power, reference 4.5.

Three of the towns in the South Essex Sewerage District are known to discharge raw sewage during power or mechanical failure according to the North Coastal Basin Plan, reference 4.7. The town of Beverly is reported to have four points of such discharge, the town of Danvers seven, and Salem one. Salem is reported to have a program for correcting its continous discharge by tie-in to SESD but has no plans as yet to correct its overflow problems.

Another situation that causes discharge of untreated sewage is when sanitary sewers join combined sewers that are surcharged, and there is no capacity for the sanitary sewage and it backs up and overflows. This is believed to be the case with some of the MSD member towns that have separate sewer systems.

Another cause of raw sewage discharges is a work stoppage. This occurred in June 1976 as the employees of the Commonwealth of Massachusetts called a general strike. While treatment at Deer Island continued, the operator shortage at Nut Island made it necessary to by-pass the treatment facilities, thus discharging approximately 140 mgd of raw sewage into Quincy Bay.

While no estimate can be made as to the number of times of overflow, nor the quantity overflowed, the information available indicates the prevalence and magnitude of the problem of raw sewage discharges in the Study Area.

3. OTHER SOURCES OF UNTREATED WASTEWATERS

There are also two other kinds of raw sewage discharges in the Study Area. These are not cataloged with the municipal discharges because they have been separately treated by EPA.

The first example is Logan International Airport located in East Boston. It is owned by the Massachusetts Port Authority, commonly referred to as MASSPORT, and is an agency of the Commonwealth. The airport discharges sewage and industrial wastes untreated into Boston Inner Harbor via some sewers which are reported to have been part of the City of Boston sewer system prior to construction of the airport. The airport discharges are not listed in the NPDES permits of either the City of Boston or the MDC, although the airport is in the service area of both agencies. The airport was issued NPDES permit No. MA 0000787 June 24, 1975 and is classed by EPA as a major * industrial private discharger. The permit authorizes the discharge of stormwater runoff at several points, untreated until December 31, 1976. Treatment is required beginning January 1, 1977. Logan International Airport is listed by the EPA as being in non-compliance with the terms of its permit. There seems to be an issue in this example as to ownership of the sewers and responsibility for abating the discharge.

The other example of raw wastes being discharged untreated into both coastal and inland waters in the Study Area is wastewaters from ships and boats. This type of discharge is regulated by two Acts of the Commonwealth as follows:

> Licensing of Marinas. Chapter 693 of the Acts of 1970, effective May 15, 1972 states that no marina shall be operated without a license issued by the DWPC and that the DWPC shall not issue a license unless such marina provides (1) adequate facilities for collection, treatment and disposal of sewage including facilities for purging and cleaning of holding tanks, the contents of which shall be disposed of to a municipal system or to an adequate treatment facility. Adequate dockside toilet facilities are also required by that act.
>
> Deposit of Refuse in or near Waters. Chapter 134 of the Act of 1970 prohibits discharges in or upon or near coastal or inland waters of trash, refuse, rubbish or debris and is stipulated to be enforced by officers of various agencies including MDC police.

---

* (EPA permit criteria for a major discharge includes high strength, toxics, heavy metals, and/or large flows.)

EPA regulations require either holding tanks and shore disposal of wastes or shipboard treatment prior to 30 January 1980.

While wastewater facilities on vessels, at piers, and at marinas are generaly not considered eligible for Clean Water Grant Assistance, the volume of wastewater therefrom if discharged to shore sewers could impact municipal or regional public facilities for conveyance, treatment and disposal.

Correction of these types of raw sewage discharges is expected to be addressed in the MAPC 208 project final report due in 1978.

C. CORRECTION OF RAW SEWAGE DISCHARGES

1. REQUIREMENTS

On October 18, 1972, Congress enacted the Federal Water Pollution Control Act Amendments Public Law 92-500. The objective of the Act "is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." To aid in the achievement of this objective, the following is included in Section 301(b) of Title III of the Act:

> "In order to carry out the objective of this Act there shall be achieved:
>
> > "(1)(b) for publicly owned treatment works in existence on July 1, 1977, or approved ... prior to June 30, 1974..., effluent limitations based upon secondary treatment as defined by the Administration..."
> >
> > "(c) not later than July 1, 1977, any more stringent limitation, including those necessary to meet water quality standards, treatment standards, or schedules of compliance, established pursuant to any State law or regulations... or any other Federal law or regulation..."

The Federal law requires a minimum of secondary treatment for all publicly owned treatment works (EPA defines an outfall sewer as a publicly-owned treatment work), making raw discharges, as well as discharges from primary treatment plants, illegal.

Subsequent to the passage of the Act, the EPA, which is charged with the enforcement of the Act, promulgated Regulations that define secondary treatment (41 CFR 133; 41 FR 30785, July 26, 1976, amending 40 CFR 133; 38 FR 22298, August 17, 1973. These regulations define the minimum level of effluent quality attainable by secondary treatment as being:

1. 5-day BOD and S.S. shall not exceed 30 mg/l (arithmetic mean for 30 days)
2. 5-day BOD and S.S. shall not exceed 45 mg/l (arithmetic mean for 7 days)
3. A minimum of 85% removal of BOD and suspended solids.
4. Effluent values for pH shall, in most cases be maintained betwee 6.0 and 9.0.

These requirements have not been applied to combined sewer overflows (see Chapter 5) or for certain industrial wastes.

In view of the fact that municipal discharges are required by July 1, 1977 to have at least secondary treatment, it appears that immediate correction of the discharges listed in Table 4-1 is necessary to meet requirements. In order to better assess the chances of such compliance, we will review the steps being taken (or planned) to eliminate these raw discharges.

2. ELIMINATION OF CONTINUOUS RAW DISCHARGES

The information on elimination of raw sewage discharges has been obtained from references 4.2, 4.3, 4.6, 4.9, 4.11 and 4.12.

a. Gloucester - North Coastal Drainage Basin. The NPDES permit issued to the Town of Gloucester authorized a continuous discharge of untreated sewage into Gloucester Harbor until June 1, 1977.

The EMMA Study reports that present plans are for the town to be served by three treatment facilities, having design capacities of 7.24, 0.31, and 0.07 mgd. However, the permit refers to the construction of the 7.24 mgd secondary facility only. It appears that the reason for deciding on three facilities is due to the high cost of constructing a consolidated system to serve those isolated areas of the town that experience tremendous seasonal fluctuations. This is due to the high trenching cost in the exposed hard rock occurring along the North Coast.

According to EPA, the State is delaying approval of the Environmental Impact Statement, which is holding up the implementation of these plants, reference 4.6. There also appears to be some question about industrial connections to the treatment facilities.

The Massachusetts Water Resources Commission, Division of Water Pollution Control,published on August 19, 1976, the proposed construction grants project list (priority list) for the fiscal year, 1977. The active list includes all those projects which can be funded under the available funds. Also included is an extended list of projects which could be funded if additional funds become available or if communities are dropped from the active list. All eligible projects must meet the requirements of the Division and the rules and regulations adopted by the EPA. The publication includes criteria used for ranking the many projects. Four Gloucester projects are on the active list for Step 3, including treatment plants, so construction grants money in 1977 is available. *

b. Lynn - North Coastal Drainage Basin. Present plans are for the wastewater flows from the towns of Lynn, Saugus and Nahant to be transported to a regional secondary plant located in Lynn. With adequate sewer service and connections, this facility should eliminate discharge of untreated

---

* (EPA advises that the Main Gloucester plant is to be funded by a State grant only and therefore is not on the priority list.)

sewage to receiving waters.

Delays in compliance with conditions of the NPDES permit (issued in November of 1974) and elimination of the raw discharge from Lynn reportedly was caused by delays in hiring of a design consultant. The problem was referred to a United States Attorney in February 1976, a complaint and summons was served in June of that year, and a regional counsel is presently reviewing the matter.

The town of Lynn is included on the 1977 active priority list for funding of a Step 2 grant for the planned treatment plant, and on the extended list for a Step 3 grant.

c. Marblehead - North Coastal Drainage Basin. Marblehead was issued a permit in May 1974, authorizing discharge to Massachusetts Bay. The permit expired on December 31, 1976, which is the date that the town was to tie into the South Essex Sewerage District. No construction grants are listed as having been made to Marblehead in the past, and the town is not on the priority list for grant assistance in fiscal year 1977. It is believed that the member communities of SESD are responsible for conveying their sewage to SESD interceptors. The EPA has advised that Marblehead does have plans to tie into the regional system. *

d. Nahant - North Coastal Drainage Basin. Nahant was issued a permit to discharge raw sewage continuously into the Atlantic Ocean. The town is scheduled to transport it's wastes to the Lynn facility in the future, and is included on the 1977 priority list for Step 2 and Step 3 grants for the design and construction of interceptors, pumping stations and force mains

---

* (EPA advises that a grant to SESD included the tie from Marblehead.)

to the Lynn regional system. The NPDES permit requires construction to begin by June 30, 1977.

e. Saugus - North Coastal Drainage Basin. Although the town of Saugus has applied for a NPDES permit authorizing a major discharge into the Saugus River, it was unissued as of July 29, 1976. The present plans are for the conveyance of the sewage to the Lynn regional facility. Construction of the necessary facilities appears to be a long way off as Saugus is not on the priority list for grant assistance. No grants are planned for facilities to export wastewater from Saugus to Lynn. The 1976 Needs Survey shows an estimated cost of $13.6 million for interceptors, pump stations and force mains, reference 4.1.

f. South Essex Sewerage District - North Coastal Drainage Basin. The South Essex Sewerage District was formed in 1925, and plans to treat and dispose of the sewage from the towns of Beverly, Danvers, Marblehead, Peabody and Salem. To handle the flows from these communities, a 41-mgd primary treatment plant is presently under construction. Current plans envision the upgrading of the plant to secondary in the future as required by the NPDES permit. The plant is being constructed in Salem, and a draft NPDES permit application has been issued to cover a discharge to Salem Harbor.

The original draft permit, if issued, would have required construction of the treatment plant to be completed by March 31, 1976, but delays have occurred due to contract negotiations. Consequently, the draft permit was revised to postpone the requirement for primary treatment.

The District is believed to be eligible for a Step 3 grant to cover interceptor construction and a Step 1 grant for a pilot study of a wastewater treatment plant. The SESD is on the extended priority list for $13.5 million.

The City of Salem continues to discharge sewage with no treatment but is on the priority list for interceptors to convey its wastewater to SESD. *

g. Medway - Charles River Basin. The town of Medway is a member of the Charles River Pollution Control District (CRPCD) which was established in 1973 to treat the wastes from Franklin, North Bellingham, and Medway. The District was awarded an $18.9 million Step 3 grant in May, 1976 for a 4.5 mgd advanced waste treatment facility. Medway is on the 1977 Construction Grants active priority list for collectors, and the CRPCD is on the same list for interceptor construction.

Although Medway presently discharges raw sewage from a portion of the town to the Great Black Swamp, no NPDES permit has been issued to establish effluent limitations although an application is pending.

h. Boston - Boston Harbor. The City of Boston was issued an NPDES permit in April of 1975 which, among other discharges, authorizes three points of untreated wastewater discharge (points No. 039,098 and 114). A report on by-passing was due in July 1976, but is reported not to have been submitted. A "15-day letter" was sent by EPA on September 24, 1976. Apparently no corrective action is planned to treat these flows.

---

* (EPA advises in 1978 that Salem's waste is discharged through the SESD system.)

i. Revere. The NPDES permit for Revere required construction of "approved remedial measures" to be completed in 1975. The EPA advises that the City has not complied with the requirements of the Permit and the matter has been referred to the Attorney General. A Consent Decree was issued April 12, 1976 extending the dates for construction to be completed for Point of Pines by December 31, 1976 and for Beachmont by July 1, 1977. Revere received a Step 1 grant May 31, 1976 but is not on the Priority List for Step 2 or Step 3 grant assistance.

j. Hull - Weymouth River Basin. In conformance with a 1969 report by Whitman & Howard, Inc., entitled "Report on Proposed Sewerage System and Sewage Treatment Facilities," we are advised that Hull is planning to construct a secondary treatment plant of 3.06 mgd capacity. A Step 3 construction grant of $8,993,250 was made in September 1975 for constructing the facility to treat the sewage. The NPDES permit authorizes the untreated ocean discharge until July 1, 1977.

The present status of the treatment plant is unknown, although it is presumed to be under construction. It is also unknown if the facilities will intercept all raw sewage discharges. *

3. CORRECTION OF INTERMITTENT FLOWS

Untreated wastewater is discharged intermittently because of several reasons. These may include overloaded downstream sewers and interceptors, pumps having inadequate capacity, screens becoming clogged due to mechanical or electric failure, loss of pumps due to electrical or mechanical failure, freezing, fuel outages, blockages, strikes, and intentional diversions

---

* (EPA advises that construction of the Hull Plant started in 1976.)

such as throttling headgates. Such actions frequently take place in the facilities of one agency and cause overflows at the upstream facilities of another agency.

In 1974, the EPA published a manual establishing design criteria for mechanical, electric and fluid systems of wastewater treatment facilities receiving Federal financial assistance under PL 92-500, reference 4.13. The document first classifies treatment works by "reliability class" based on the acceptability of receiving water damage due to effluent quality degredations. It then specifies, by reliability class, backup requirements for mechanical apparatus, unit operations and auxilliary power.

Those treatment facilities funded for construction after the date of publication of that manual must have the standby equipment necessary to accomplish satisfactory treatment of the sewage in the event of a power failure, breakdown, or need for facility repairs.

While the older sewage facilities, as well as these not funded by the Federal Government, were not required to comply with the reliability criteria mentioned, by-passes could be greatly reduced by incorporating those requirements in future projects. It is not known whether this is actually being done, although the present MDC permit does contain the requirement for stand-by power to provide primary treatment in the event of a power failure. No time schedule for implementation of this provision is found in the permit however.

The solution to discharges that occur as a result of surcharged sewers is not necessarily an increase in sewer capacity. The problem may be best corrected by reducing excessive infiltration or inflow.

Improved sewer maintenance practices, addition of gratings at inflow points, and the enactment and enforcement of proper sewer ordinances can all assist in preventing blockages due to grease, trash or other materials which tend to physically clog a sewerage system.

Where raw sewage is by-passed because of ice formation damaging machinery, consideration should be given to covering the machinery for insulation against wind evaporative losses. A non-structural option is to dispose of street ice and snow in another manner.

The occurance of by-passing due to strikes or other labor problems has been rare but it has happened in the MDC system within the past year. A contingency plan can be developed to assure continued operation of all essential facilities under these conditions.

D. SUMMARY OF CHAPTER 4

1. An approximation of the amount of continuous raw sewage discharges occurring in the Study Area that could be verified from available data is shown below:

Parameter	Emission	Units
Average daily flow	62	mgd
Peak flow rate	125	mgd
BOD	102,500	pounds per day
Suspended solids	102,500	pounds per day

An assessment of the magnitude of intermittent overflows and by-passes cannot be made.

2. Our review of the raw sewage problems indicates that most of the continuous raw sewage dischargers are in the peripheral area. For most of them primary treatment facilities are being planned or are under construction or the projects on the 1977 priority list for Clean Water Grant Assistance to do so. Delays are reported to have occurred for a variety of reasons such as either local "do-nothing" attitudes or problems in compliance with grant procedures, environmental regulations, or in lack of agreement with regional agencies.

The prevalent intermittent by-passes and overflows seem to have received lower priority efforts toward correction in the foreseeable future.

3. The largest raw sewage discharges in the Study Area are the South Essex Sewer District with an estimated flow of 26 mgd and the City of Lynn with an estimated flow of 25 mgd.

The South Essex Sewer District has a primary plant under construction to serve five member communities and an agreement to upgrade to secondary in the future.

Lynn is reported to be taking no steps toward abatement of raw sewage discharges, in spite of administration letters and orders. The matter has been referred to the U.S. Attorney resulting in civil action in the form of a summons and complaint for violation of NPDES conditions and seeking relief and costs.

4. Only one of the forty-three Metropolitan Sewerage District member communities is entirely sewered to the MSD. Several communities that are members of regional agencies continue to intermittently discharge raw sewage through overflows or by-passes. Over 90 percent of the MSD members have NPDES permits for separate discharges. There also are many continuous raw sewage discharges from sewered portions of communities not connected to regional agency interceptors.

5. One MSD member community, the City of Revere, has had enforcement action taken against it for continuing discharges of raw sewage from two areas of the City not connected to MSD interceptors. That case has been referred to the Attorney General of the Commonwealth of Massachusetts and a consent decree has been issued agreeing to a delayed schedule for correction of the problem.

6. No communities proposed by the EMMA Report to be annexed as possible future members of the Metropolitan Sewerage District are found to be discharging raw sewage at present.

7. It is readily apparent that not all present raw sewage discharges in the Study Area will be corrected with assistance from the present Clean Water Grant Program before current funding allotments expire in September 1977.

8. An issue that evolves from this topic could be:

> "Should a regional agency extend service to new communities before fully serving the needs of its present member communities?"

REFERENCES

4.1 Dames & Moore/U.S. EPA
Computer Printout of 1976 Needs Survey for Study Area
Municipalities (Preliminary) January 24, 1977.

4.2 Metcalf & Eddy et al
EMMA Study, Main Report
March 1976.

4.3 Massachusetts DWPC, Water Quality Section, Westborough
"The Charles River (above Watertown),"
1976 Part D Water Quality Management Plan
Preliminary, for Review Only, January 1976.

4.4 Metcalf & Eddy, Inc./MDC
"Engineering Report on Wellesley - Framingham
Interceptor System"
1965.

4.5 EPA, New England Regional Office
"Joint Task Force Report on Major Manned M.D.C.
Facilities in the Greater Boston Area"
said to be a draft, but not so marked.
May 1976.

4.6 EPA
NPDES Non-compliance Quarterly Report for
May, June and July 1976,
September 14, 1976.

4.7 Massachusetts DWPC, Water Quality Section
"North Coastal Planning Area - 1975
Water Quality Management Basin Plan"
July 1975.

4.8 MAPC
"208 Interim Output I"
Preliminary Copy, May 10, 1976.

4.9 Joint EPA/Massachusetts DWPC
NPDES Permits for various
communities and regional agencies
in the Study Area
Jointly issued in 1974, 1975 and 1976.

REFERENCES (Continued)

4.10 MDC, Sewerage Division
"Fifty-sixth Annual Report
FY ending June 30, 1975"
August 21, 1975, and
"Fifty-seventh Annual Report FY ending June 30, 1976"
October 14, 1976.

4.11 Massachusetts DWPC
"Construction Grants Project List
for Fiscal Year 1977" (Priority List)
Proposed August 19 , 1976, Adopted November 1976.

4.12 EPA, Construction Grants Section
Status of Applications Pending and
Grants Information and Control
System Status Report
September 28, 1976.

4.13 USEPA, Office of Water Program Operations
"Design Criteria for Mechanical, Electric,
and Fluid System and Component Reliability"
Technical Bulletin EPA-430-99-74-001.

Contents

Chapter 5

COMBINED SEWER OVERFLOWS

Section | Page
A. COMBINED SEWER SYSTEMS AND THEIR OVERFLOWS 5.4
  1. Development of Existing Combined Sewer Systems 5.4
  2. Combined Sewer Overflows 5.10
  3. Problems in the Combined Sewer Systems 5.23

B. REQUIREMENTS FOR COMBINED SEWER OVERFLOWS 5.28
  1. Commonwealth of Massachusetts 5.28
  2. Local Policy 5.29
  3. National Recognition 5.30
  4. NPDES Requirements 5.36
  5. Enforcement Compliance Schedule Letter 5.46

C. PREVIOUSLY PROPOSED FACILITIES 5.49
  1. Facilities Constructed 5.49
  2. Proposed Plans Not Implemented 5.52
  3. Present Planned Projects 5.58
  4. Separation of Combined Sewers 5.62

D. ANALYSIS OF EXISTING OVERFLOW STATIONS 5.65
  1. Cottage Farm 5.66
  2. Somerville 5.74
  3. Cost Analyses 5.80
  4. Impact on Overflow Problems 5.85
  5. Alternative Overflow Treatment 5.87

E. SUMMARY 5.90

REFERENCES 5.97

Figure 5-1 Location of Combined Sewer Overflow Problems 5.9

Figure 5-2 Plan of Cottage Farm Station 5.67

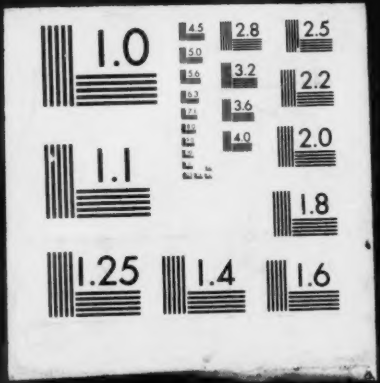
Figure 5-3 Plan of Somerville Station 5.75

Table 5-1 Costs of CSO Facilities 5.82

5 OF 8

PB

296 551


1.0
4.5
5.0
5.6
6.3
7.1
8.0
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

Chapter 5

COMBINED SEWER OVERFLOWS

The Metropolitan Sewerage District serves nearby two million people with over 5,000 miles of local sewers. Approximately one-fifth of the sewered areas tributary to the MSD system have combined sewers, which serve a population of nearly one million people. Outside the MSD system, in the North Coastal area, there are at least seven other communities within the Study Area which also have combined sewer systems, reference 5.1.

Perhaps as many as 400 overflow points exist as part of the combined sewer systems in the Study Area.* These overflow points discharge into various surface waterways, either into one of the major rivers, the Boston Harbor or along the Atlantic shoreline. The problem of combined sewer overflows has been affecting water quality in the Boston Harbor for decades. It has been identified as the biggest pollution abatement problem affecting the Boston Harbor and it tributaries, deserving high priority in pollution control, reference 5.2.

The Information Packet of May 1975 prepared for public hearings on the EMMA Study states:

> "Although pollution from combined sewer overflows is only intermittent and has been estimated to occur on the average of about five or six times a month for short periods of time, the location of such discharges makes them a deterrent to the effective use of the Boston Harbor as a recreation resource."

and

---

* (EPA advises they feel there are closer to 200 overflows inspite of published reports of more than 300 in the combined sewer area of Boston alone.)

> "During rainstorms the discharge from combined sewer overflows in terms of BOD is estimated to be about equal to the Deer Island plant effluent but in terms of SS it is more than ten times as much."

While the actual quality of Deer Island effluent including by-passes and sludge discharge, has not been measured, the rate of emission of combined sewer overflow pollutants is estimated to be equivalent to 260,000 pounds of BOD per day and 2 million pounds of suspended solids per day.

In Volume 8 of the EMMA Report, urban stormwater pollutants were forecast for the year 2000 for all watersheds in the Study Area. The basis was 1-year return frequency, 24-hour duration, 50 storms a year and an antecedent dry period of 5 days. The results predicted from separate urban stormwater systems for only the watersheds tributary to Boston Harbor are cited here for comparative purposes for the annual design storm:

Parameter	Loading	Units
BOD	135,500	Pounds
Suspended solids	555,500	Pounds

Previous chapters have provided a history of Boston's sewers, an examination of technical problems related to wastewater facilities planning and an overview of the EMMA Study. Chapter 4 was directed to the existence and impacts of raw sewage discharges in the various Boston area basins. This chapter focuses on the status and effectiveness of the existing combined sewer overflow regulation facilities.

The present situation with regard to combined sewer overflows is identified in this chapter. It includes enumeration of overflows, description of overflow systems, present and proposed detention/treatment facilities and present operating conditions. Excluded are examinations of existing separated sewer systems and of the wastewater treatment facilities discussed previously in Chapter 2.

Present regulations and requirements concerning combined sewers and combined sewer overflows are reviewed in this chapter, including local legislative acts, EPA regulations and NPDES permit restrictions.

Plans for combined sewer overflow corrections that have been proposed, constructed or rejected are summarized herein. This chapter includes an examination of the present policy toward the combined sewer overflow problem and the success of sewer separation projects to date.

There are two combined sewer overflow treatment facilities in operation within the Study Area. Another is designed and under construction. Particular attention is given to the operational data reported for the present facility known as Cottage Farm Combined Sewer Detention and Chlorination Station which discharges into the Charles River. The operational frequency and reported efficiency of the Cottage Farm Facility are reviewed and analyzed in this chapter. The Somerville Marginal Conduit Pretreatment Facility is also reviewed.

As a part of this study, the capital and the operation and maintenance costs associated with the combined sewer overflow detention/chlorination facilities are examined.

A. COMBINED SEWER SYSTEMS AND THEIR OVERFLOWS

Efforts to solve the problems of pollution in the Boston Harbor by construction of sewage treatment plants have been only partially successful because of the existence of hundreds of miles of combined sewers having over 200 overflows. Several studies have indicated that elimination of combined sewers by storm water separation is not cost-effective. They concluded that treatment/detention was the only feasible alternative.

1. DEVELOPMENT OF COMBINED SEWER SYSTEMS

In 1709 the Massachusetts General Court (Legislature) established rules that regulated the construction, ownership and maintenance of all common sewers and drains. For over a century following this enactment, Massachusetts achieved unmatched sanitation standards for land and cellar drainage, with toilet wastes explicitly excluded from such drainage systems.

The year of 1833 marked the beginning of Boston's combined sewer system. For the first time, fecal matter discharges to drains was allowed by the City. Later, in order to aid in flushing sewage solids and debris from the combined sewers, discharge from roof drains to the sewers was also allowed.

The established combined sewer system expanded greatly by mid-19th Century. Increased discharges of untreated sewage and storm water flowed from miles of additional sewers and created pollution of Boston Harbor. As Boston continued to grow, conditions worsened with regard to pollution of the surface waters. As a building practice, roof drainage and sewage drainage of buildings and housing continued to be combined at or in the structures. Extensive land filling of tidal areas for development relocated the Harbor shoreline, necessitating extending various combined sewer discharge lines. The relatively flat gradient of the extended outfalls resulted in accumulation of sludge and debris within the sewers and around outfall discharge points. In addition, the outfalls were subject to tidal action several hours daily, further creating sludge deposition in the sewers. Many sewer extensions were installed on reverse grade.

During the late 19th Century, sewer conditions grew still worse. Sewage backed up into houses during high tides, pollution in the Boston Harbor and other discharge locations created public nuisances and health hazards. Increased evidence of sewer system inadequacies led to the creation of the Massachusetts State Board of Health, which soon began urging major improvements in the combined sewer system. In 1875 a special commission appointed to study the existing system recommended construction of a main drainage system south of the Charles River and another north of the Charles River. These drains were to discharge screened sewage through deeper outfalls located further out in the Boston Harbor, near Nut Island and Deer Island.

Prior to the completion of these main drainage systems near the turn of the century, the Boston Main Drainage Sewer System had been conceived, constructed and placed into operation by the City of Boston. This system was designed to collect dry weather sewage flows plus small amounts of storm water from the City of Boston. It included a pump station at Calf Pasture and an outfall sewer to Moon Island where 50 million gallons could be stored in basins for release to Boston Harbor during ebb tide. No attempt was made to intercept combined sewer overflows during wet weather.

Subsequent sewer system planning and construction was also directed primarily toward sewer interception and transporting sewage to the existing main drainage outfalls at Moon, Deer and Nut Islands. Projects included the Ward Street Headworks (1967) and tunnel connection to Columbus Park headworks, and a tunnel from Columbus Park to Deer Island (1968), Chelsea Creek Headworks and tunnel to Deer Island (1967), plus various relief sewers, and primary sewage treatment plants at Deer and Nut Islands.

The forementioned projects focused upon the problems of dry weather sewage flows in the combined sewer systems of the North and South Metropolitan Sewerage Districts. Combined sewer pipelines, outfalls and treatment facilities capacities were designed to accept only small amounts of wet weather stormwater. To handle excess stormwater flow, additional overflows were provided at various locations along trunk sewer lines. Most overflows discharge into local waterways, i.e. rivers, estuaries, harbors and along the shoreline. Until 1967 no plans or projects involving treatment of combined sewer overflows had been incorporated in the pollution abatement efforts in the Study Area. The Camp, Dresser and McKee study on "Improvements to the Boston Main Drainage System," reference 5.3., concluded that, at that time:

> "no projects had been planned or constructed that would significantly improve water quality in the Boston area."

That Report recommended the "deep tunnel plan" for elimination of the combined sewer overflows. This plan and its apparent demise are discussed later in this chapter.

The first planned and constructed facility directly aimed at the pressing problems of pollution due to combined sewer overflows was the Boston University Bridge Detention and Chlorination Station. The station's name has since been changed to Cottage Farm combined Sewer Detention and Chlorination Station. Following the construction of that facility, the Somerville Pretreatment Facility was built to serve some of the overflows to the Mystic River from the Somerville area. Present plans exist for constructing a third facility designed to serve combined sewer overflows near the new Charles River Dam.

The forementioned pretreatment or detention/chlorination facilities constitute the present extent of combined sewer overflow abatement in the Study Area. Most of the untreated combined sewer overflows continue to discharge untreated wastes into the various receiving waters in the Boston Area.

Thomas R. Camp stated in an article entitled "The Problem of Separation in Planning Sewer Systems," WPCF Journal pp. 1959, December 1966 that:

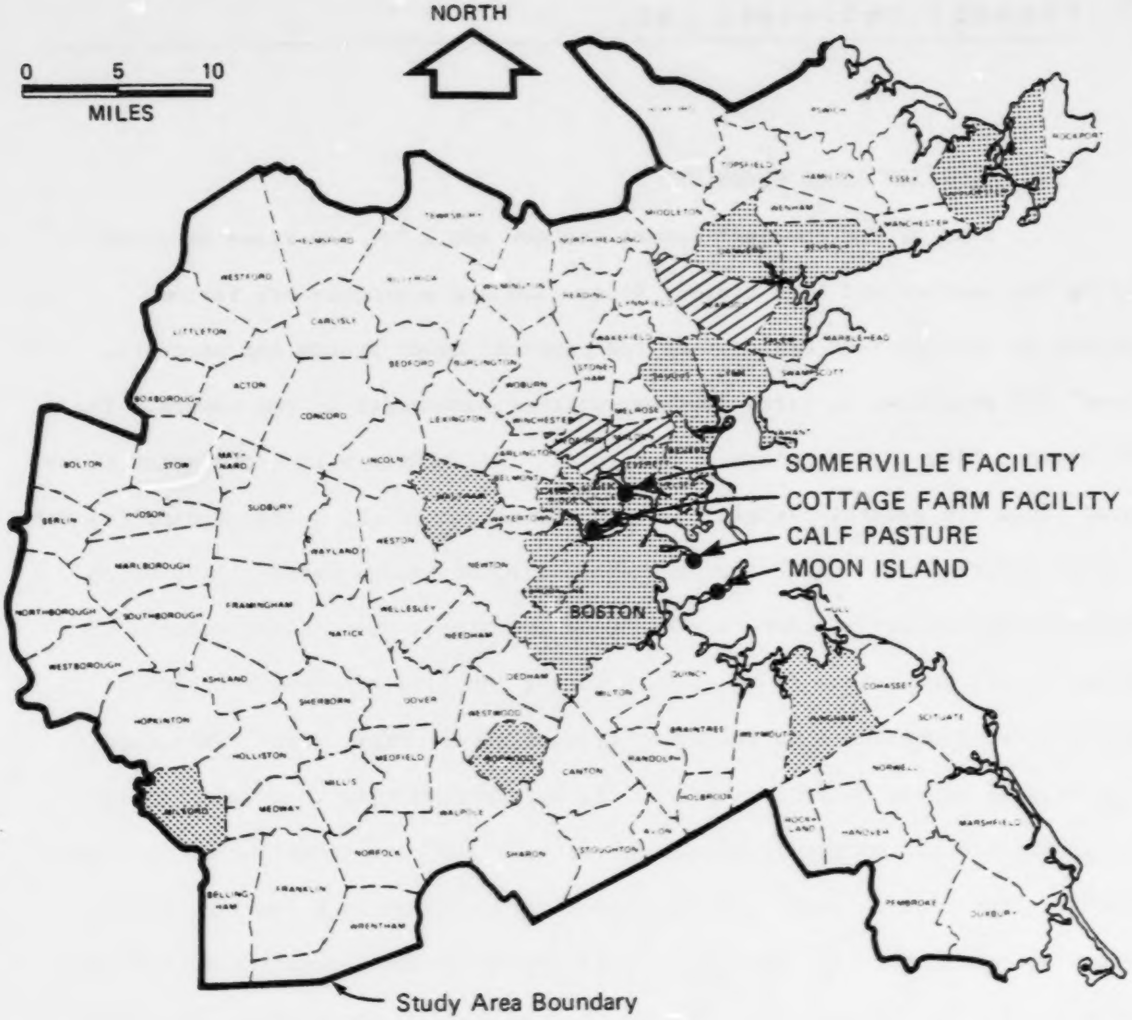
> "At the present time there are about 387 combined sewer outlets in Metropolitan Boston of which 261 serve the City of Boston."

and

> "It has long been known that with this (combined sewer) practice only about three

> percent of the annual production of sanitary wastewater is discharged untreated with storm water to the nearest watercourses.
>
> The fact that only about 3 percent of the sanitary wastewater produced in a year is discharged untreated is no cause for complacency because the discharges will occur every 5 to 7 days, on the average, with any rainfall exceeding about 0.04 inches per hour. The slugs of pollution are particularly damaging in slow moving waters such as a basin or tidal estuary because they cannot purge themselves of the pollution before the next rainfall occurs."

The location of Study Area communities with identified combined sewer overflow problems is shown in Figure 5-1.


NORTH
0
5
10
MILES
SOMERVILLE FACILITY
COTTAGE FARM FACILITY
CALF PASTURE
MOON ISLAND
BOSTON
Study Area Boundary
TOPSFIELD
HAMILTON
ESSEX
ROCKPORT
MIDDLETON
WENHAM
MANCHESTER
TEWKSBURY
NORTH READING
CHELMSFORD
WESTFORD
BILLERICA
WILMINGTON
READING
LYNNFIELD
CARLISLE
LITTLETON
MARBLEHEAD
WAKEFIELD
BEDFORD
BURLINGTON
STONEHAM
SWAMPSCOTT
BOXBOROUGH
ACTON
WOBURN
CONCORD
LEXINGTON
WINCHESTER
MELROSE
BOLTON
STOW
MAYNARD
LINCOLN
ARLINGTON
BELMONT
BERLIN
HUDSON
SUDBURY
WATERTOWN
WAYLAND
WESTON
MARLBOROUGH
NEWTON
NORTHBOROUGH
SOUTHBOROUGH
FRAMINGHAM
WELLESLEY
NATICK
NEEDHAM
WESTBOROUGH
ASHLAND
DEDHAM
QUINCY
SHERBORN
DOVER
WESTWOOD
MILTON
HOPKINTON
BRAINTREE
WEYMOUTH
COHASSET
SCITUATE
HOLLISTON
MEDFIELD
NORWOOD
CANTON
RANDOLPH
MILLIS
HOLBROOK
MILFORD
MEDWAY
WALPOLE
NORWELL
ROCKLAND
HANOVER
MARSHFIELD
NORFOLK
SHARON
STOUGHTON
AVON
BELLINGHAM
FRANKLIN
PEMBROKE
DUXBURY
WRENTHAM

LEGEND

▦ COMBINED SEWERS AND OVERFLOWS

▨ OVERFLOWS

NSF Boston Case Study, Phase II Evaluation

LOCATION OF COMBINED SEWERS OVERFLOW PROBLEMS

Kennedy Engineers, Inc. 1977

Figure 5·1

Basemap: EMMA Report

2. COMBINED SEWER OVERFLOWS

Many of the combined sewers are too small for the flows received during wet weather and high tides. Hydraulics and economics are factors leading to insufficient capacity of the combined sewer system and hence the "need" for overflows to carry away wet-weather surcharges in the sewers. The dry weather flow is hydraulically very small in comparison to storm water flows. Sewer pipes are generally sized to carry solids out of the system during the dry weather sewage flow. Where the pipes are sized for storm water flows, which might exceed the dry weather flow by 50 to 100 times, significant amounts of sewage solids accumulate in the sewers during low flow, dry weather periods unless sewer slopes were increased or special sewer shapes used. This deposition creates septic conditions within the system resulting in offensive odors. Also, periodic storms can flush the deposited solids out overflows or to plants creating treatment problems. Construction cost savings in a combined sewer system were historically realized by using pipes of insufficient size and compensating for wet-weather flows by use of overflows in the system. Resulting overflows were formerly considered to have only minimal pollutant impacts because it was considered that the stormwater would provide dilution to the sanitary sewage. As more hydraulic capacity was needed, parallel relief sewers were often constructed to increase flow capacity. In some instances, conduits were constructed to relocate the point of discharge to locations considered less sensitive to pollutant loads. Some separation of combined sewers has occurred by the construction of separate pipelines, primarily in redevelopment areas, however, in virtually all cases, these separate pipelines have been rejoined and discharge back into combined sewers.* Such actions have lead to the present combined sewer overflow system and its resultant problems.

a. Location of Overflows. Determining the extent to which combined sewer overflows exist in the Study Area from the data available has proven to be less definitive than hoped. General listings of overflows permitted, reported or referenced in various studies to date have been made available from several different sources. An undetermined number of overflows and cross-connections between separate systems are not clearly documented but have been reported to exist in many areas. An attempt however has been made to express the number and locations of combined sewer overflows in order to establish the importance of the problem of controlling these overflows.

The following summary of combined sewer overflows has been compiled from references 5.4, 5.5 and the NPDES permits for the Sewerage Districts and communities within the Study Area. The actual amounts of overflow and their exact location of discharge is not reported in most cases. As an organizational framework, the overflows are enumerated by community according to the principal drainage basin in which the community is generally situated.

(1) Charles River Drainage Basin. Nineteen combined sewer overflows are reported from Cambridge sewers. Four overflows are reported in Waltham. Milford is noted to have several overflows, though not enumerated.

---

* (In some cases, dry weather flow goes to MDC interceptors and wet weather excess flow goes to combined sewers or storm drains.)

The existence of a combined sewer system in Brookline indicates the probability of overflows in that community also. All of these communities, except Milford, are members of the MDC. In addition, the MDC system has eight major overflows plus the Cottage Farm Facility located in this Basin. In summary, at least thirty-four combined sewer overflows are documented in this basin plus numerous others reported to exist. (All City of Boston overflows are included in the Boston Harbor group).

(2) Neponset River Drainage Basin. The only community in this basin with documented combined sewers is Norwood which reports twelve overflows from its system. Norwood is a member of MSD.

(3) Mystic River Drainage Basin. Ten overflows are reported for the community of Somerville. Stoneham has two overflows on record. Both are members of the MSD. There are also nine overflows from MSD interceptors, some of which are located in the communities of Medford and Malden even though these communities do not have combined sewers. This makes a total of 21 in the Mystic River Basin.

(4) North Coastal Drainage Basin. The communities of Lynn, Nahant, and Saugus have reported numbers of overflows of four, six and unknown, respectively. These areas are members of the Lynn regional system. The communities of Beverly, Danvers and Salem report four, seven and one overflow respectively. They are members of the South Essex Sewer District which has seven additional overflows in this basin. One of the SESD overflows is reported to be in the community of Peabody. Gloucester, which is outside the MAPC Study Area, reportedly has seven overflows in its combined sewer system. The total number of identified overflows in its combined sewer system. The total number of identified overflows in this basin is at least thirty-seven.

(5) Weymouth Drainage Basin. Only the Hingham community reportedly has combined sewers. No overflows are reported but there is the

probability that one or more exists. There also is a documented overflow from the MDC interceptor in Hingham, making at least two.

(6) Boston Harbor Drainage Basin. All six communities in this region are members of the MSD. Four communities have combined sewers with points of overflow as follows: Boston has seventy-four points of intermittent combined sewer overflow, one pair of outfalls from Moon Island holding tanks and forty-seven storm water overflows with "possible sanitary connections"; Chelsea has eight combined sewer overflows; Everett and Revere also have combined sewers and probable overflows. The MSD system also has one overflow from the North Metropolitan Trunk Sewer in Winthrop. These overflows into Boston Harbor (and adjacent tribuaries thereto in the City of Boston) total 133.

(7) SuAsCo, Ipswich and North River Drainage Basins. Communities in these basins reportedly have no combined sewers within their boundaries.

From this inventory we have found that over 239 known combined sewer overflows exist within the study region.

The above accounting is in addition to the discharges from the MDC Cottage Farm and Somerville stations and overflow/by-passes at Deer Island and Nut Island treatment plants and discharge to surface waters from the Chelsea Pump Station.

At least six surveys of combined sewer overflows have been made, starting with the 1936 survey reported in House Document No. 1600. There is little correlation between surveys. The 1968 state survey lists

405 outlets into Boston Harbor alone, some of which are separate storm water outlets, however, reference 5.6. The City of Boston stated in 1970 that there were over 300 combined sewer overflows in the five core area cities alone, reference 5.7.

We find no completed program wherein an attempt has been made so far to measure flow rate and duration, and to determine the strength of the existing discharges from all combined sewer flows in the Study Area.

Several major studies are being presently conducted which are expected to yield additional information on combined sewer overflows:

(1) The I/I study of the MDC facilities in the Deer Island Service area,

(2) The I/I studies of the MDC facilities in the Nut Island service area, and

(3) The MAPC sponsored survey of 49 communities in the 208 area that are not members of the MDC.

These surveys are expected to be completed by the end of 1977 but do not include sewers of member communities. No surveys are known to exist or be under way for the 17 communities in the EMMA Study Area which are outside the MAPC Study Area.

b. Effects of Overflows on Receiving Waters. Merely enumerating the number of overflows in the combined sewer system does not indicate the magnitude, frequency, or impact of resultant overflows of combined sewage and storm water upon the environment. One high flow discharge point into a semi-closed drainage basin would more than likely have a greater pollutant impact than several small discharges into a large well-flushed drainage basin. For this reason, the overflow system must also be examined relative to frequency of operation, duration and rate of flow, strength of flow and condition of receiving waters.

(1) Frequency and quantity of overflows. In 1947, McKee estimated, from studies on rainfall in Boston over a 12 year period, that overflows of mixed untreated sewage and storm water would occur five to six times per month. He determined that a storm intensity of 0.01 inch per hour (after impervious surfaces are well wetted) would produce run-off equal to the dry weather sewage flow. For portions of the sewer system sized for twice the average dry weather flow, 2.7% of all raw sewage in the system was estimated to overflow into receiving waters, reference 5.8. It should be noted that it is an estimate, as there is no record of frequency, duration and flow rate reported on any overflows.

The "Interim Report on Combined Sewer Overflows in Boston Harbor" in 1971 examined 125 major overflows to Boston Harbor and its tributaries. Eight of the studied overflows exist along the Dorchester Interceptor which reportedly has its capacity exceeded over 90 times per year. In fact, the interceptor's capacity of 40 cfs was capable of being exceeded by the peak dry weather flow alone in 1970. The report further estimated that by the end of this century the East Side Interceptor, West Side Interceptor and the Alewife Brook Sewer may have their capacities exceeded by peak dry-weather flows also. Four larger systems are also reported to experience the same problem prior to the year 2020.

The study also examined 5-year, 10-year and 15-year frequency rainfalls for each combined sewer system within that Study Area. Calculated quantities of overflows in 1970 ranged as follows: for a 5-year storm, overflow rates of 30 to 750 cfs (275 cfs av.) would occur with durations of 1 to 8 hrs. (3 hr. av.). This would indicate 22 million gallons of overflow for the storm. Overflow rates of 30 to 900 cfs (333 cfs av.) would occur with durations of 1 to 8 hrs. (3 hrs. av. during a 10-year rainfall) which indicates 27 million gallons of overflow. Overflow rates of 30 to 950 cfs (350 cfs av.) for an average duration of 3 hrs. would indicate 28 million gallons of overflow during a 15-year rainfall, reference 5.9.

More recent work reported in Volume 7 of the EMMA Study indicates even greater quantities of combined sewer overflows occur. The study modeled the combined sewer system using 69 major points of overflow but confined its scope to the MSD combined sewer areas. (The EPA Storm Water Management Model was used in that study). The results for a 1-year design storm with an eight hour runoff period indicated a peak overflow rate of 13,000 cfs or 8400 mgd, reference 5.10. This figure is over 45 times the average 5-year storm overflow reported in the earlier study. This eight-hour rate of combined sewer overflow is seventy-five times the average daily flow now accepted by the Deer Island treatment plant.

(2) Quality of overflows. The quality of the combined sewer discharges is influenced by several independent, non-uniform factors. Such factors include, among others: the quality of surface runoffs entering the

sewers, the proportion of dry-weather domestic sewage and industrial wastes versus storm water flow, the amount of inflow and infiltration affecting the system, the amount of sludge deposition resuspended and the period of time between storms. It is also affected by street sweeping practices.

Surface runoff quality is affected by the land use from which it comes: whether roadways, residential, farming, industrial or some other use. Surface runoff should not be considered clean water. Major contaminants borne in surface runoff considered in the EMMA Report have been characterized as having the following pollutant compositions:

(a) Suspended Solids content can be about three times that of untreated sewage and are largely inorganic solids.

(b) Biological Oxygen Demand (BOD) concentrations of runoff generally equal the strength of secondary treatment plant effluent.

(c) Coliform counts in runoff are between one-fourth and one-half those in raw sewage, but up to five orders of magnitude higher than those considered safe for water contact recreation use, references 5.10 and 5.11.

In addition, runoff usually contains a range of other pollutants not measured by the above parameters. These include gross settleable solids, floatables and screenable materials, as well as heavy metals and other toxic constituents. Roadway runoff includes lead (from gasoline), asbestos (from brake linings) and salt (from ice control).

We have reviewed past reports to assess the magnitude of the combined sewer overflow pollutional loadings. Volume 7 of the EMMA Study reports on the modeling conducted to estimate the present amount and quality of combined sanitary/stormwater that overflows from 69 locations in the five core area cities. The results for the modeled one-year design storm overflow event are reported as 75,100 pounds of BOD and 795,480 pounds of suspended solids emitted into 13,000 cubic feet per second (cfs) of water flowing for 8 hours (equivalent to 8,400 million gallons per day). The estimated bacterial concentration in the same overflows is reported to range from one-thousand to 100-million coliforms per one-hundred milliliters of the overflow (10 to 1,000,000 MPN/ml).

An overflow event is compared to the effluent discharged from the Deer Island treatment plant to give order-of-magnitude significance. During an eight-hour wet-weather period, the combined sewer overflow mixtures were estimated to contain approximately the same amount of BOD, about fifteen (15) times the suspended solids, and millions of times the bacterial concentrations that Deer Island emits during an average 8-hour period. Not mentioned is the fact that the overflows also contain unmeasured other pollutants and fecal solids and other aesthetically unacceptable substances which are normally removed by sedimentation, screening, and skimming operations in the sewage treatment process.

In 1971, the "Interim Report on Combined Sewer Overflows," reference 5.9 analyzed 125 overflows and determined estimated waste loads discharged during a 5-year frequency rainfall. The loadings were estimated from the ratio of dry-weather flow (averaging 180 mg/1 BOD and 150 x 10^6 coliform organisms per 100 ml) to storm runoff (averaging 40 mg/1 BOD and 10^5 MPN/100 ml coliform count). Resulting overflow discharge values from the 5-year storm resulted in an average BOD_5 concentration of 56 mg/l and 16 x 10^6 MPN/100 ml coliform count. From the overflow rate, overflow duration and pollutant concentration used in the report it is estimated that 10,275 pounds of BOD_5 would be discharged during the 5-year frequency storm into the Boston Harbor alone.

Data results from the EMMA Study and from the "Interim Report on Combined Sewer Overflows" differ significantly. The EMMA Study indicates over seven times the BOD discharge from a 1-year storm than the Interim Report indicated from a (larger) 5-year storm. Each apparently studied the same sewer systems and Study Area. The EMMA Study results were derived from sampled discharge water quality and rainfall data which were then input to quantity and quality models. On the other hand, the Interim Report utilized data from other agencies within the Study Area.

A further aspect of the quality of combined sewer overflows is the intermittent discharges of floating matter, debris and undisinfected fecal waste into the various waterways. These create not only aesthetic nuisances but constitute a danger to the public health. The mere presence of such materials creates significant pollutional impact in the eyes of the public. The problem really is not only the overall volume of pollution being spilled into the receiving waters of the Harbor but also health and nuisance problems created by what is discharged.

(3) Overflow impacts on receiving waters uses. In 1967, the Commonwealth of Massachusetts classified its various bodies of water as to use and degree of cleanliness. Class "C" and "SC" waters should be

suitable for aesthetic enjoyment, recreational boating and a habitat for fish and wildlife common to the area. Bodies of water which receive combined sewage overflows and are classed "C" include the Charles, Neponset and Mystic rivers and their major tributaries. Class "SC" waters include the Inner Harbor and tidal reaches of the Charles, Chelsea and Mystic Rivers. The requirements for these areas stated that there should be no floating solids, scum, grease or oils, and no sludge deposit in them. Exceptions include discharges from waste treatment facilities which provided "appropriate treatment."

Water classified "SB" should be of good aesthetic value, suitable for certain shell-fisheries use, for bathing and other water-contact recreational activities and should be excellent fish habitat. Coliform bacteria were limited to not more than 2,300 in no more than 10 percent of the samples per month and median coliform counts were not to exceed 700. Also, "SB" waters were to be free of scum, floating solids and sludge deposits. Waterways which are classified "SB" and are affected by combined sewer overflows include Dorchester Bay, parts of Winthrop Bay and the tidal section of the Neponset River, reference 5.9.

During the past decade, the preservation or attainment of the forementioned water quality goals in the Boston Area watercourses has not been successful due, in major part to the continuing combined sewer overflow problem. In May 1974, DWPC introduced new Rules and Regulations for the Establishment of Minimum Water Quality Standards which revised the 1967 standards and established specific water quality criteria for the various classifications of receiving waters. No specific coliform limits were established, however, for "SC" and "C" class waters. The Standards state that "no bacteria limit has been placed because of the urban runoff and combined sewer problems which have not yet been solved."

Coliform bacteria data were collected by the DWPC during part of 1972 in the Boston Harbor, reference 5.12. Data from six gaging stations revealed post storm coliform counts of up to 930,000 MPN/100 ml, which was tenfold the counts taken from dry weather periods. Both fecal and total coliform counts followed this trend, and clearly indicated the impact of combined sewer overflows on the Harbor waters, reference 5.10.

The combination of sewer overflows and tidal fluctuations resulted in the Public Health recommendation in 1970 that bathing be restricted at Tenean Beach on Dorchester Bay during low tide or after rainfall above a certain minimum, reference 5.13. Temporary closures of other beaches have also occurred. Surveillance of coliform counts continues along Boston's beaches as a necessary public health precaution. The magnitude of the problem can best be realized by recalling that over 150 combined sewer overflow points exist within the Harbor Basin.

Shellfish areas in Winthrop Bay, Dorchester Bay and tidal portions of the Neponset River have been "closed" to the harvesting of shellfish primarily due to combined sewage overflow in those basins. However, shellfish harvesting in these "closed" areas was observed by the study team.

The Charles River Basin has numerous overflows into its waterways. The area was intended to be one of America's most beautiful and useful watercourses. Several problems of pollution have hindered its usefulness and beauty in the past, but some steps are being taken in an attempt to correct them. These include upstream wastewater treatment facilities improvements, construction of a dam near the Rivers mouth to control saltwater intrusion and by the construction of the Cottage Farm Facility to handle some of the combined sewer overflows. Remaining overflows however continue to impair the Basin's waterways. There is also a large accumulation of organic sludge in the Back Bay Fens, on which there have been attempts at removal. A particular problem exists near and in the Back Bay Fens where the largest reported increased coliform counts occurred following rainfalls. The importance of controlling combined sewer overflows can not be overstated. This basin in particular can be subject to oily residues, sediment accumulation, and foul odors resulting from the degredation of accumulating sludge deposits.

Many previously useful beach areas along lakes, streams and the Atlantic seaboard can no longer be made available to the public. Public beaches no longer exist around the Lower Mystic Lake. Magazine Beach along the Charles River is no longer available for recreation. Temporary closure of various coastal beaches including the popular Dorchester Bay beaches continues to occur. Shellfish harvesting has been prohibited also in several coastal areas. Commercially taken shellfish in permitted areas must still be purified before distribution to markets. All of these limitations on the use of various waters and beaches are the direct result of public health hazard conditions in these areas due to excessive sewage waste concentrations. A primary source of such excesses is the addition of raw sewage during combined sewer overflows. Until overflows can be eliminated, treated or otherwise adequately controlled, beaches and waterways will remain in jeopardy of further loss of usefulness.

3. PROBLEMS IN THE COMBINED SEWER SYSTEMS

The combined sewer systems in the Study Area involve miles of sewers and interceptors, numerous pumping stations, tidal gates at outfall structures and some overflow treatment facilities. All of these items require inspection, cleaning, maintenance and repair at times, involving large numbers of workmen and considerable annual expenditure.

The combined sewers in and around Boston which are tributary to the MSD system are the largest system within the Study Area. As such, its system's problems have the greatest impact upon the regions' water quality. Hence, it warrants the greatest examination as to the condition and operation of its sewer facilities.

Several factors, whether independently or in combination, can produce overflows. While the primary cause is rainfall runoff entering the combined sewer systems, the extent and frequency of the overflows is related to other factors. These factors can be segregated into three major problem producing areas: tidal, mechanical and structural. The following therefore is an overview of several problems presently affecting the combined sewer system of MSD, resulting in larger and/or more frequent overflows.

a. Tidal Influence. The combined sewer systems in the Boston Area have outfall discharges and overflow structures which are submerged in tidal waters. In an effort to prevent saline tidal waters from entering the system at such locations, tide gates were installed. However, historically the maintenance and operation of these gates have been inadequate. Tide gate malfunctioning allows salt water to enter the sewers, frequently causing upstream sewer overflows due to the hydraulic capacity being taken up by the intruding waters.

"The Interim Report on Combined Sewer Overflows" stated that in 1969, 24 percent of the measured flow at the Deer Island treatment plant was from salt water inflow associated with unrepaired, malfunctioning tide gates. The report further stated that many regulators, which control sewage and stormwater flows between local sewers and the interceptors and outfalls, were blocked and contributed to overflow conditions. Also, during low tides raw sewage was being discharged through various outlets to receiving waters because of the disrepair of tide gates and regulators, reference 5.9.

The recent "Joint Task Report on Major Manned MDC Facilities," reference 5.14, stated that infiltration and open tide gates resulted in high chloride concentrations and numbers of salt water fish entering the sewer system from the north Hingham area into the Nut Island system, creating high flow conditions in the system. High flows to Hingham station result in overflows to the Back River which sometimes results in closure of clam flats in the area, reference 5.14. This subject is also treated in Chapter 6.

b. Mechanical Breakdown. The primary mechanical features in the combined sewer system which can create overflows are the various pumping stations. Although little difficulty has occurred in the four major pump stations serving Nut Island Treatment Plant, they lack the built-in reliability of automation, instrumentation and duplication of units. The Hingham Station must be by-passed on occasion due to sewage flows exceeding the station's capacity as noted previously.

Three off-site headworks serve the Deer Island Raw Sewage Pump Station. They include Chelsea Creek (350 mgd), Columbus Park (182 mgd) and Ward Street (256 mgd). Operationally, flow to the Deer Island Plant is controlled by throttling the influent gates at the headworks to avoid exceeding the limited pumping capacity at Deer Island. Throttling and overflow occur even during peak dry weather flows. When the sewers are backed up, flow can be diverted from the Ward Street headworks to the Charles River via Cottage Farm, flow from Chelsea Creek can be diverted to Winthrop via the East Boston electric and steam pump stations, and flow can be diverted from Columbus Park to Moon Island via Boston's Calf Pasture pump station.

The primary reason for sewer back up at the three headworks stations is inadequate pumping capacity at the Deer Island Pump Station. A major cause of inadequate pumping at Deer Island is that not all installed pumps are available to operate at design capacity. The Task Force Report on Facilities stated that in April of 1976, only five of the nine units were operational and two of them had speed restrictions. Two units had been out of service for a year, two others for a few months at that time. It was further reported that the plant has been down to two operating pumps on occasion.

When flows into Columbus Park headworks exceeds the capacity of the Deer Island Pump Station for any reason, the City of Boston must activate the Calf Pasture Pump Station to remove backed up sewage in the system to Moon Island facility and into the Harbor. This constitutes a major combined sewer overflow into the Harbor. The City maintains a 24-hour watch at the Calf Pasture Pump Station and at Moon Island and is prepared to activate these overflow facilities as needed.

Upon any activation of the Moon Island discharge, it is to be reported to the Quincy Health Department which, in turn, closes the Quincy Beaches. This reporting is required by the NPDES permit and overflows occur about 25 times a year. The volume of discharge from this overflow until recently has not been reported. A recently reported activation of Calf Pasture on August 28, 1976 indicated that over 19 million gallons were discharged during a few hours of operation.

c. Structural Limitations. The primary structural limitations placed upon the combined sewer sytem are the age and capacity of the piping itself. Many of the local sewers and MDC interceptors were constructed prior to 1900. Increased water use and increased tributary areas has caused overloading of many sewers. In order to avoid excessive surcharge pressures witin these old sewers, overflow reliefs have been constructed.

"The Interim Report on Combined Sewers Overflows," reference 5.9, determined that many of the combined sewers may be exceeded in their capacity by the dry weather flows alone in the year 2020. Peak dry weather flows were to exceed the Dorchester Interceptor's capacity in the first part of this decade.The fact that insufficient capacity existed ten years ago in many of Boston's sewers is well documented in the 1967 CDM report, reference 5.3. The old brick 126-inch Boston Main Drainage system interceptor under Massachusetts Avenue collapsed due to structural failure. The 1975 Supplement to the 1967 report constitutes a facilities plan for four projects to improve portions of the Boston Main Drainage System but will not solve the combined sewer overflow problems in the City of Boston, reference 5.15.

B. REQUIREMENTS FOR COMBINED SEWER OVERFLOWS

A combined sewer is defined as a sewer receiving both intercepted surface runoff and municipal sanitary sewage and/or industrial wastewater. A combined sewer overflow is flow, in excess of interceptor capacity, from a combined sewer that is discharged into a receiving water.

The requirements for dealing with the acknowledged adverse effects of untreated overflows from combined sewers has been the subject of various state and national legislative acts, policies and guidelines. Nationwide, the EPA has not yet developed a consistent or definitive policy on combined sewer overflows. Some Regions have virtually prohibited them while others have taken no definite stand on what control will be required.

1. COMMONWEALTH OF MASSACHUSETTS

The Massachusetts Legislature enacted Chapter 485 of the Acts of 1907 which established a program of separation of combined sewers in order to reduce the frequent pollution caused by combined sewer overflows. The 1907 law made it mandatory for communities with combined sewers to spend annually an amount in proportion to their taxable valuation for the separation of sewers, reference 5.15. It appears that this law has not been fully implemented in the Boston area.

The 1974 "Rules and Regulations for the Establishment of Minimum Water Quality Standards and for the Protection of the Quality and Value of Water Resources" infer that combined sewer overflows should conform to the minimum standards regarding all constituents in all classes of waters except for the following footnote:

> "No bacteria limit has been placed on Class "C" and Class "SC" waters because of the urban run-off and combined sewer problems which have not yet been solved. It is the objective of the Division to eliminate all point and non-point sources of pollution and to impose bacterial limits on all waters."

Most of the combined sewer overflows occur in water classified as B, C, SB and SC.

2. LOCAL POLICY

It is the offical policy of cities and towns in Massachusetts having combined sewers to separate those sewers pursuant to State law. This policy is implemented whenever a combined sewer is destroyed due to regrading or otherwise in need of replacement. The way it is implemented is that the local area is reconstructed with separate storm drain pipes and sanitary sewer pipes; however, at the edge of the reconstruction project, the parallel pipelines in nearly all cases are joined together into the combined sewer system.

The major examples of separation of sewers in this manner have been carried out by the City of Boston Redevelopment Agency (BRA).

The second session of the Conference in the Matter of Pollution of the Navigable Waters of Boston Harbor and its Tributaries April 30, 1969, conferees agreed to implementation plans set forth by the Commonwealth for the various municipalities, reference 5.16. The plans were to:

> 1) Complete the repair of tidegates in the City of Boston by May 1971, and
>
> 2) Eliminate flows at City of Boston's Calf Pasture Pump Station and Moon Island disposal Facility by March 1972.

3. NATIONAL RECOGNITION

The first federal appraisal of the combined sewer problem was a 1964 U.S. Public Health Service in-depth study on the pollutional effects of storm water and overflows from combined sewer systems, reference 5.17.

In 1965, Congress authorized a Research, Development, and Demonstration Program to find remedial alternatives at a lower cost than complete sewer separation. This program is today in EPA under the Storm and Combined Sewer Technology Branch of the National Environmental Research Center, Cincinnati, with major emphasis directed toward combined sewer overflows. Research has also been conducted by the National Science Foundation, reference 5.11.

Since that time, legislation has been passed which recognizes the special problems of combined sewer overflows. A legal decision has been made and NPDES permits have been issued which address the subject in the Boston Area.

a. Water Quality Act of 1965. Section 6 (a)(1) of the Water Quality Act of 1965 first recognized the storm water problem by authorizing grants for the purpose of

> "controlling the discharge into any waters of untreated or inadequately treated sewage or other wastes from sewers which carry storm water from or both storm water and sewage or other wastes...." (Emphasis added).

b. Federal Water Pollution Control Act Amendments of 1972 (PL 92-500). The 1972 Amendments include in section 212 "Definitions" the following:

> "Treatment works means any devices and systems used in the storage, treatment, recycling and reclamation of municipal sewage or industrial wastes of a liquid nature to implement section 201 of this Act....
>
> ...(and) in addition means any other method or system for preventing, abating, reducing, storing, treating, separation or disposing of municipal waste, including storm water runoff or industrial waste, including waste in combined storm water and sanitary sewer systems...which comply with section 301...."

Section 301(b)(1)(B) states that there shall be achieved by

> "July 1, 1977... effluent limitation based upon secondary treatment as defined pursuant to section 304(d)(1) of this Act."

Section 304(d)(1) states that the Administration...

> "shall publish...information in terms of amounts of constituents and chemicals, physical, and biological characteristics of pollutants, on the degree of effluent reduction attainable through the application of secondary treatment."

On April 30, 1973, Notice was published in the Federal Register that the EPA was proposing to issue regulations in secondary treatment pursuant to section 304(d)(1) of the Act. Comments were made as to the difficulty of achieving 85 percent removal of BOD and suspended solids during wet weather for works receiving flows from combined sewer systems. Recognizing this, a paragraph was added which allows a waiver of the secondary treatment requirement on a "case-by-case basis."

The Secondary Treatment Regulation was published August 17, 1973 as 40 CFR 133. It specified the minimum levels of effluent quality attainable by secondary treatment in terms of the parameters of BOD, suspended solids, fecal coliform bacteria, and pH. It contained two special considerations, one of which was:

> "(a) Combined sewers. Secondary treatment may not be capable of meeting the percentage removal requirements of paragraphs (a)(3) and (b)(3) of § 133.102 during wet weather in treatment works which receive flows from combined sewers (sewers which are designed to transport both storm water and sanitary sewage). For such treatment works, the decision must be made on a case-by-case basis as to whether any attainable percentage removal level can be defined, and if so, what that level should be."

The Secondary Treatment Regulations were amended as recently as July 26, 1976 (to delete the fecal coliform requirement) but the special conditions on combined sewage treatment remains in the regulations. The regulations are silent on the degree of treatment required for combined sewer overflows.

c. Program Guidance Memorandum PG-61. Program Guidance Memorandum PG-61 is entitled "Grants for Treatment and Control of Combined Sewer Overflows and Stormwater Overflows" and is also labeled "Program Requirements Memorandum 75-34." It was issued by EPA Headquarters as a part of July 26, 1976 Construction Grants Program Guidance Manual Supplement No. 1 behind a cover letter stating that adherence to the provisions of Program Requirements Memoranda (PRM) will be binding on Regional Administrators.

The Memorandum includes the following planning requirements:

> "Where detailed planning has been completed, treatment or control of pollution from wet-weather overflows and by-passes may be given priority for construction grant funds only after provision have been made for secondary treatment of dry-weather flows in the area."
>
> Grants may be approved only if planning has thoroughly analyzed for the 20-year planning period:
>
> (1) Alternative techniques to attain various levels of control (related to alternative beneficial uses, if appropriate) including consideration of all alternatives described in "Alternative Waste Management Techniques and Best Practicable Waste Treatment," Section C, Chapter III.
>
> (2) The costs for various levels of control appearing to be feasible,
>
> (3) The benefits to the receiving waters, and
>
> (4) The costs and benefits of addition of AWT processes to dry weather flow of the area.

Criteria required for project approval for grant assistance include:

> (1) The project must be necessary to protect a beneficial use of the receiving water after technology based standards required by section 301 of

PL 92-500 are achieved by industrial point sources and at least secondary treatment for dry weather flows,

(2) Provision has been made for funding secondary treatment of dry-weather flows,

(3) The technique for controlling combined sewer overflows is cost-effective, and

(4) Marginal costs are not substantial compared to marginal benefits.

It should be noted that the above regulations apply only to eligibility for grant funding. They do not apply to schedule of implementation or treatment level necessary to protect water quality or to meet discharge requirements.

d. Decision No. 49. Decision No. 49 of the General Counsel of the U.S. EPA on Matters of Law was made June 30, 1976 relative to effluent limitations applicable to combined storm water/sanitary outfalls of the City of Boston and the MDC. The decision was at the request of the Commonwealth which contended that the combined sewer outfalls at issue are point sources and must have permits containing effluent limitations consistent with best practicable control technology (BPT) currently available.

Findings of that Decision are as follows:

(1) Issue of Law No. I: "Does the Regional Administrator have the authority to issue NPDES permits which do not require effluent limitation based on secondary treatment...?"
Conclusion: "NO..."

> (2) Issue of Law No. II. "Does the Regional Administrator have the authority to issue permits which do not require effluent limitations based on best practicable control technology (BPT) or secondary treatment for storm water runoff to be installed by July 1, 1977?"
> Conclusion: "No. What limitations constitute BPT for individual storm sewers is a matter within the discretion of the Regional Administrator."
>
> (3) Issue of Law No. III. "Does the Regional Administrator have authority to issue permits which do not require effluent limitations based on BPT or secondary treatment for combined sewer (overflows) and by-passes to be installed by July 1, 1977?"
> Conclusion: "No."

In discussions which follow the conclusions, it is stated that:

> "Since no nationally applicable eflfuent regulations prescribing "BPT" for combined sewer overflows have been promulgated, the determination of BPT for the individual overflows is a matter within the discretion of the Regional Administrator, pursuant to Section 402(a)(1) of the FWPCA."

It is also noted that the permits for the City of Boston and the MDC:

> "do not contain effluent limitations applicable to the discharges from the combined storm water/sanitary system outfalls. They are defective in their failure to do so."

4. NPDES REQUIREMENTS

In the Commonwealth of Massachusetts, NPDES permits have been issued jointly by the U.S. EPA Region I and the Massachusetts Division of Water Pollution Control pursuant to Section 401(a)1 of the Federal Act and Chapter 21, Sections 26-53 of Massachusetts General Laws. Each agency has the independent right to enforce the terms and conditions of the permits. Permits become effective 45 days after issuance.

Many of the permits issued to municipalities in the Study Area contain requirements regarding combined sewer overflows. Examples of such requirements are abstracted below:

a. Town of Norwood.

Permit No. MA0101486 was issued to the Norwood Board of Selectment, December 27, 1974. It authorizes 12 discharges of untreated combined wastewater/stormwater overflow to Meadow Brook and the Neponset River until June 15, 1976, subject to General Condition 19. Implementation Schedule and Reporting Requirements.

(1) General condition 19 is as follows:

"GC 19. Bypasses

a. The diversion or bypass of any discharge from which treatment facilities utilized by the permittee to maintain compliance with the terms and conditions of this permit is prohibited, except

(1) where unavoidable to prevent loss of life or severe property damage, or

(2) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the terms and conditions of this permit.

The permittee shall immediately notify the Regional Administrator and the Director in writing of each such diversion or bypass in accordance with the procedure specified above for reporting non-compliance.

b. Pollutant discharge resulting from bypass flows and overflows of the permittee's sewerage system are subject to this permit. Such discharges (such as those attributable to combined sewers) could cause serious problems in the receiving waters. Prior to setting specific effluent limitations on such discharges, additional information is required. The permittee shall submit such information to the Regional Administrator and the Director as specified in Special Condition B. The submittal shall identify and locate such discharges and shall, as a minimum, describe the extent and causes of such discharges, estimate the frequency and duration of such discharges, describe the effect on the receiving waters, and contain such additional data as is available to the applicant. The permittee shall also submit its preliminary long-range plan of abatement for these discharges. This permit condition shall not abrogate responsibility of the permittee to supply additional information requested in any federal permit application form.

The Regional Administrator and the Director reserve the right to make appropriate revisions to this permit in order to establish any appropriate effluent limitations, schedules of compliance, or other provisions which may be authorized under the Federal and State Acts in order to bring all such discharges into compliance with these Acts."

(2) The Implementation Schedule requires steps be performed as follows:

(a) By December 20, 1975, have in effect a sewer use ordinance,

(b) By June 15, 1976, report on bypasses and/or overflows, and,

(c) Progress reports by June 16, 1975 and March 15, 1976.

(3) The Reporting and non-compliance section of the permit requires the permittee to submit written notices of compliance or non-compliance within 14 days following each date.

b. City of Waltham.

Permit No. MA0101842 was issued June 2, 1975 to the City of Waltham and authorizes, until July 1, 1977, the discharge of untreated wastewater/storm water overflow from three points into the Charles River and from one point to Chester Brook, subject to conditions and reporting requirements.

The conditions are similar to those for Norwood above except in the case of Waltham, the following additional items are required on the implementation schedule:

(1) By July 1, 1975, submit a report on an I/I study,

(2) By November 1, 1976, submit final plans, and

(3) By May 1, 1977, award construction contract.

The implementation schedule states also that the wastewater treatment facilities to be constructed shall be designed to provide a minimum of secondary treatment or any more stringent limit required.

(Note: DWPC advises that Norwood, Revere, Stoneham, Waltham and Milford do not have combined sewers even though they are permitted to discharge combined sewage.)

c. City of Cambridge

Permit No. MA0101974 was issued December 31, 1974 to the City of Cambridge. It authorizes, until July 1, 1977, discharges of untreated wastewater/stormwater overflow from 4 points to Alewife Brook and from 15 points to the Charles River, subject to conditions, reports, and plans for facilities construction similar to that for the City of Waltham, but without the minimum treatment level requirement.

d. Town of Stoneham

Permit No. MA0102059 was issued on June 12, 1975 to the Town of Stoneham and authorized the Department of Public Works to discharge untreated wastewater/stormwater overflow at two points to Sweetwater Brook (Aberjona River) subject to conditions. (The permit expired April 1, 1976.) The schedule requires that by August 1, 1975, a report be submitted recommending a program for eliminating the discharges from combined sewers with a minimum of secondary treatment or any more stringent limit required.

e. City of Chelsea

Permit No. MA0101877 was issued to the City of Chelsea December 16, 1974 and authorizes its Street and Sewer Department to discharge untreated stormwater/sanitary sewage overflows subject to conditions as follows:

(1) Until June 1, 1977, from 5 points to the Chelsea River and from one point to Island End River, and

(2) Until February 28, 1975 to discharge from one point to the Mystic River and from another point to the Chelsea River, at which time the discharges shall be terminated.

Permit conditions are similar to those for Norwood.

f. City of Somerville

Permit No. MA0101982 was issued December 27, 1974 to the City of Somerville and authorizes its Department of Public Works to discharge until July 1, 1977 untreated stormwater/sanitary sewage overflow from 10 points, 4 to Alewife Brook, 4 to the Mystic River, 1 to the Charles River and 1 to Millers River, subject to conditions and an implementation schedule. The schedule requires:

(1) By January 1, 1975, engage a consulting engineer.

(2) By January 1, 1976, submit plans.

(3) Commence combined sewer manhole reconstruction by April 1, 1976.

(4) Complete combined sewer manhole reconstruction by April 1, 1977.

The balance of the requirements are similar to those for Waltham.

g. City of Revere

Permit No. MA0102024 was issued to the City of Revere Department of Public works December 30, 1974. It authorizes discharge of untreated storm water/sanitary sewage overflow from the Beachmont area to the Atlantic Ocean until December 31, 1975, subject to various requirements including commencing construction of approved remedial measures by May 1, 1975 and completion of construction by December 31, 1975. The remedial measures are required to include elimination of sewage from the discharge.

h. Town of Gloucester

Permit No. MA0100625 was issued to the City December 23, 1974 and authorizes until July 1, 1977 the discharge of untreated storm water/wastewater overflow from 5 points to Gloucester Harbor and from 2 points to the Annisquam River subject to General Condition 19.

i. City of Lynn

Permit No. MA0100552 was issued to the City November 8, 1974 and authorizes until June 30, 1977 the discharge of screened storm water/sanitary sewage overflow to Lynn Harbor and the discharge of untreated storm water/sanitary sewage overflow to the Saugus River and to two other points in Lynn Harbor, subject to General Condition 19.

j. South Essex Sewerage District

Permit No. MA0100501 in draft form would authorize until June 30, 1977 untreated storm water/sanitary sewer overflows to the Porter River, to Beverly Harbor, and to the Bass River. It also would authorize bypasses of untreated wastewater to the North River Canal and to Salem Harbor which occur during wet weather.

k. City of Boston

Permit No. MA0101192, was issued to the City of Boston Department of Public Works April 2, 1975. It authorizes 125 discharges of untreated stormwater/sanitary sewage overflows and bypasses to Boston Harbor and tributaries until June 30, 1977, subject to special conditions including:

(1) No new wastewater flows will be allowed to connect to the city system unless prior written approval is obtained from the Massachusetts Division of Water Pollution Control and the MDC,

(2) When the Moon Island Facility is operated, the sewage shall be held until 15 minutes after high tide and only be released on outgoing tide conditions and it shall be chlorinated and monitored for

Flow
BOD
TSS
Total Coliform,
Fecal Coliform, and
Times of discharge.

The chlorination facilities shall be installed prior to May 1975.

(3) The City shall notify the Quincy Commissioner of Public Health when a discharge occurs from Moon Island,

(4) The permittee, in coordination with MDC, shall operate the system to minimize the discharge of pollutants from combined sewer manholes,

(5) No new sources of inflow shall be connected into any separate sewers in the sewer system,

(6) The permittee shall report flow rates and design an operational plan to minimize the discharge of pollutants, and

(7) A report shall be submitted on the separation of sanitary and industrial waste connections from storm sewers, giving priority to discharges to Class B Waters,

(8) The same permit also states all tide gates shall be checked at least twice a year, the inoperative ones repaired and the report made on the status of repairs and reason for non-repair given.

1. Metropolitan District Commission

Permit No. MA0102351 (state No. M-180) was issued to the Metropolitan District Commission August 12, 1976 and expires May 1, 1981. In addition to covering effluent limitations for the treatment plants, the permittee is authorized to discharge untreated storm water/sanitary sewage overflow subject to conditions until July 1, 1977 from:

(1) 18 sewer overflows in the north system, and,

(2) 1 sewer overflow in the south system.

(3) It also authorizes discharges from the treatment plants through 4 reliefs when the capacity of the deep-water outfalls is exceeded.

(4) After July 1, 1977, the overflows shall receive the best practicable control technology currently available, as defined by the Regional Administrator.

(5) Other conditions related to the combined sewer overflows include:

(a) The diversion or bypass of any flow in permittee's sewage system from waste treatment facilities used to maintain compliance with this permit is prohibited except where unavoidable to prevent loss of life or severe property damage or where excessive storm drainage or runoff would damage facilities necessary for compliance with this permit.

(b) The permittee (MDC) shall immediately notify the Regional Administrator and the Director by phone and verify in writing of of each such diversion or bypass.

(c) The permittee, in cooperation with its member communities shall operate the treatment plant and total sewer system to minimize the discharge of pollutants from combined sewer overflows or bypasses.

(6) Cottage Farm Detention Station. Until expiration of this permit, the permittee is authorized to discharge treated storm water/wastewater overflow to the Charles River. All flows shall receive, as a minimum, screening, chlorination and detention prior to discharge. All flows discharged shall contain a minimum chlorine residual of 1.0 mg/l at all times.

(7) Somerville Marginal Conduit and Pretreatment Facility. Until expiration of this permit, the permittee is authroized to discharge treated storm water/wastewater overflow from the Facility to the Mystic River. All flows shall receive, as a minimum, screening and chlorination prior to discharge. All flows discharged shall contain a minimum chlorine residual of 1.0 mg/l at all times.

(8) The permit requires surveys, reports, monitoring, and compliance with schedules including the following:

An operational plan to minimize the discharge of pollutants from combined sewer overflows and bypasses submitted one month after issuance of the permit. The plan shall refine the maximum treatable flow, report on operation and performance of regulators, report on storage capacities upstream from all control devices, provide a plan to use at least 80% of available capacity upstream from regulators such as pump stations, and provide a method to determine if storage was used before any discharge from a combined sewer system.

(9) The permit requires 14 construction projects to be completed by July 1, 1977, including
Neponset River,
Charles River,
Dorchester Bay
Inner Harbor, and
Charles River Marginal
combined sewers.

(10) Monitoring requirements include identification and location of all overflows and bypasses, description of extent and cause, frequency and duration, and effect on receiving water and identification of those that will be eliminated by proposed projects, initial report to be submitted January 1, 1977.

(a) Discharges from Cottage Farm are required to be recorded and monitored for
Flow
BOD
pH
Settleable Solids
Chlorine Residual
Total Coliform
Fecal Coliform

(b) Discharges from Somerville Marginal Conduit and Pretreatment Facility and the (future) Charles River Marginal Conduit Project are to be similarly monitored.

(11) Emergency action - Electric Power failure. The permittee shall, in the event the primary source of power fails, provide, as a minimum, primary treatment (or its equivalent) plus disinfection for all wastes discharged.

The dates in the MDC permit have been changed by the Enforcement Compliance Schedule Letter of August 11, 1976.

5. ENFORCEMENT COMPLIANCE SCHEDULE LETTER

As noted in Chapter 1, the 16-page letter to the MDC was issued jointly by the EPA Enforcement Division and the Massachusetts Division of Water Pollution Control on August 11, 1976 and is referred to as the Enforcement Compliance Schedule Letter or ECSL.

The ECSL was accepted by MDC continget upon project authorization and appropriations, completion of EISS (by EPA), review and approval of grant applications (by EPA and DWPC) and with no responsibility for delays caused by parties other than MDC.

The modifications to NPDES permit No. MA 0102351 as a result of the ECSL pertaining to combined sewer overflows are as follows:

a. Criteria.

(1) Hydraulic Criteria. "All combined Sewer Overflow Projects shall be designed and constructed such that untreated discharges of combined sewage shall not occur at rainfalls less than a storm of 1 year severity and 6 hour duration."

(2) Process Criteria. "After completion of the Combined Sewer Overflow Projects, all flows shall receive, as a minimum, screening, chlorination and detention prior to discharge. All flows discharged shall contain a minimum chlorine residual of 1.0 mg/l at all times."

We choose to call these Process Criteria because they loosely dictate a process (which is expected to provide little treatment) while at the same time they do not specify meaningful limitations on either effluent quality or on receiving water quality.

(3) Technology. The ECSL also states: "after submittal of the operational plan for minimizing pollutants from the combined sewer overflows and bypasses, the Regional Administrator will determine the best practical control technology (BPT) currently available and inform the permittee, as relating to discharges 006-023 and 106 of this permit." It is noted that the first 18 are in the Deer Island System and the last discharge is in the Nut Island System.

b. EIS. It is noted that none of the combined sewer overflow projects are dependent upon an EIS.

c. Schedules.

(1) Charles River Marginal Conduit Project. This is EPA grant project No. MA 250312 for which a Step 3 grant was awarded May 28, 1975, and the initial grant contract was dated November 6, 1975, in the amount of $18.9 million. The ECSL stipulates that

(a) By March 1, 1979 complete construction, and

(b) By March 1, 1979 attain operational level to meet the effluent limits specified above.

(2) Dorchester Bay and Charles River Projects. The Charles River Project includes facilities to control pollution from overflows into Muddy River and Back Bay Fens.

(a) By January 1, 1977 initiate a facilities plan (Step 1),

(b) By July 1, 1978 submit the facilities plan,

(c) By January 1, 1979 initiate preparation of final plans and specifications (Step 2),

(d) By July 1, 1980 submit final plans and specifications,

(e) By January 1, 1981 award the construction contract (Step 3),

(f) By February 1, 1983 complete construction, and

(g) By February 1, 1983 (same date as above) attain operational level.

(3) Neponset River Project. Same as above projects except facilities plan is required six months sooner.

(4) Boston Inner Harbor Project. The scheduled events are to begin one-year later than the other new projects, and end 3-years later, January 1, 1986.

C. PREVIOUSLY PROPOSED FACILITIES

As stated earlier in this chapter, surface water pollution in the Boston area due to combined sewer overflows has been acknowledged as a major problem since the turn of the century. This acknowledgement of the problem resulted from aesthetic and health conditions which could not be ignored. Remedial actions have been proposed over the last seventy years. This section will examine the various proposed corrections of the overflow situations, including projects constructed, projects rejected and projects under consideration or planned for implementation.

1. FACILITIES CONSTRUCTED

Some new facilities have been added to the combined sewer system and others upgraded in an attempt to provide improvement in overflow management. Additions provide only indirect benefits in some cases. Constructed improvements vary in their scope and intent from merely rebuilding or repairing existing facilities to building new facilities to provide overflow containment, treatment, diversion or a combination of these.

One of the earliest comprehensive engineering efforts to evaluate pollution problems in the Boston Harbor and its tributary streams resulted from Massachusetts House Documents No. 1600 of 1936 and No. 2465 of 1939. Subsequent preliminary designs recommended that storm overflow relief sewers be provided in the Charles and Mystic River basins in particular. Funds were later authorized for the construction of various storm overflow relief sewers in the late 1940's. These projects, however, merely diverted the overflows to other waterways, as there were no treatment facilities provided in the system until 1952.

Other facilities within the combined sewer system have been constructed to provide additional capacity for stormwater transport in order to reduce overflows. The facilities at Calf Pasture Pump Station and Moon Island were phased out of full-time operation after the construction of treatment facilities at Deer Island. Calf Pasture and Moon Island, however, were and still are maintained as combined sewer relief facilities capable of handling about 155 MGD. They are used to divert wet weather flows to the Boston Harbor to reduce the overflows right at the shoreline. Similar provisions of added wet weather flow diversion reportedly exist at the East Boston pumping stations which is capable of diverting 120 MGD from the Chelsea Creek Headworks to the Winthrop Terminal Facility (built in 1970). Winthrop in turn is capable of pumping 60 MDG (peak) to Deer Island and/or 60 MGD to discharge directly into the Harbor untreated.

The facilities at Moon Island and East Boston are old facilities retained as standby and can handle some of the flow of the combined sewer system. They are manned and maintained merely as emergency diversion systems to minimize local overflow discharges whenever possible. No significant treatment is provided by the operation of these stations. They are emergency diversion facilities only, which move the discharge points to deeper water in the Boston Harbor.

Two new facilities are now in operation which are intended to provide some combined sewer overflow pollution abatement. The Cottage Farm

Combined Sewer Detention and Chlorination Station is designed to serve the North and South Charles Relief Sewers and the Charles River Valley Sewer. The Somerville Pretreatment Facility serves a portion of the City of Somerville. Both facilities were built by MDC.

The Cottage Farm Detention and Chlorination Station (originally named the Boston University Bridge Detention and Chlorination Station) is located adjacent to the Charles River just above the Boston University Bridge. It is designed to accept, screen, chlorinate and detain combined sewer overflows from portions of the North and South Charles sewerage systems prior to the discharging into the Charles River. It's design capacity is given as 233 MGD. It is intended to function as merely a holding tank during minor overflows, discharging back into the sewers following the high-flow period. It is to serve as a pretreatment facility prior to discharge to the Charles River during overflow periods which exceed detention capacity. Collected screening and settled solids can be washed back into the North Charles Relief Sewer for treatment at the Deer Island plant following an overflow event. The station was first activated in 1971. Further discussion and analysis of this overflow treatment facility is included in this chapter.

The Somerville Pretreatment Facility is located below the Amelia Earhart Dam on the Mystic River. It reportedly is "designed to treat about 160 MGD prior to overflowing to the Mystic River tidal waters," reference 5.10. The Facility is equipped with screening and chlorination facilities, but it does not detain any of the flow as provided at the Cottage Farm

Facility. Further discussion of this Facility also is included in this chapter.

Indirectly related improvements in the combined sewer system which aid in limiting overflows are the various tide gate replacement and repair programs undertaken recently. Benefits gained by reducing inflow of tidal waters into the sewer system should be considered improvements in providing better management of overflow conditions. The inflow issue will be discussed further in Chapter 6. The forementioned facilities and construction undertakings cover the primary actions taken to date in providing combined sewer overflow abatement. They constitute those remedial action alternatives which have been constructed.

2. PROPOSED PLANS NOT IMPLEMENTED

Various studies have been made in recent years which, at least in part, focus upon abatement of pollution due to combined sewer overflows in the Boston Area. Some of these reports recommended improvements aimed at local or regional pollution correction which have not been implemented. Some of these proposals are summarized in chronological order as follows:

a. The Deep Tunnel Plan. This proposal was developed for the City of Boston in 1967 in an effort to correct all the combined sewer overflows existing in Boston, Cambridge, Brookline, Chelsea and Somerville, reference 5.18. The Deep Tunnel Plan was selected over three other alternatives. The other alternatives studied included:

> "1. Complete separation of all sanitary sewerage and storm drainage systems in areas now served by combined sewers,

> 2. Construction of chlorination/detention tanks at selected locations to receive flows from tributary combined sewerage systems of mixed sewage and stormwater in excess of dry weather interceptor capacities, detain the flows to provide chlorine contact time for disinfection and discharge chlorinated flows to nearby watercourses or to the harbor, and
>
> 3. Construction of surface holding tanks at selected locations to receive flows... in excess of dry weather interceptor capacities, and discharge untreated flows to the dry weather interceptors following storms."

These constitute the major traditional methods of approaching the combined sewer issue. The new method recommended utilized collection, storage, treatment and deep water disposal. The plan was of such a large scale that it could handle the worst storm that ever occurred in Boston, 8.4 inches of rainfall in one day. The plan included collecting the area's overflows into transmission tunnels which would flow into a system of five 33-foot diameter radial storage tunnels constructed deep in solid rock. These would converge to a central chamber 300 feet below Columbus Park. From this chamber the flows would cross under the Harbor in another 33-foot diameter storage tunnel. This main tunnel would terminate near Deer Island, where the flow would be screened and chlorinated at a pumping station. This pumping station would lift the flow through a 9.5-mile long discharge pipe to twin diffusers set about 100-feet deep in Massachusetts Bay.

The estimated costs presented for the four alternatives indicated that the tunnel plan was the most economical. The following tabulated estimated costs were reported based on 1967 dollars at an ENR of 1100:

	Estimated Costs, Million Dollars		
Method	Construction*	Capitalized Operation and Maintenance	Total
Complete Separation	$550	$ 34	$584
Chlorination Detention Tanks	400	133	533
Holding Tanks	715	99	814
Deep Tunnel Plan	430	66	496

*The several increments of construction were not reduced to present worth.

Recommendation of the tunnel plan was also based upon other factors including minimal surface land requirements and adequacy of the system to perform under severe conditions.

A recent report "Practices in Detention of Urban Stormwater Runoff," reference 5.19, stated:

> "From a cost standpoint, it is thought that the deep tunnel plan should be more economical (percentage-wise) in 1974 than it was in 1967."

The report further stated that the plan had been approved by both the City of Boston and the Commonwealth of Massachusetts. No reasons for the lack of funding and implementation of the plan were given.

While the cost advantages of the deep tunnel plan may improve as tunneling techniques advance and as projected maintenance costs for the other alternatives increase, any comprehensive solution to the overflow problem was shown to be very costly. Implementation of the entire plan would require a regional approach be adopted by five communities, although costs were also given for a reduced plan just for the City of Boston. Implementation would need State and Federal financial assistance.

b. The Old Harbor Area Pollution Control Plan. This proposal was aimed at controlling combined sewer overflows which exist in Old Harbor, which is the portion of Dorchester Bay near Columbus Park, reference 5.20. The plan was developed for the City of Boston to reduce overflows at L Street and at Carson and City Point Beaches by diverting the combined sewer flows around the perimeter of the Harbor to the Reserved Channel. Diversion was to be accomplished by a series of new gravity collection conduits and forcemains. The diverted flow would pass through a new chlorination/detention facility at Castle Island prior to discharge. Solids removal was to be included. Construction cost was expected to exceed $33 million, according to the 1970 report by CDM.

It was anticipated that this proposal would be implemented following the signing of a 1972 bill which provided money for preventing sewage overflows adjacent to the bathing beaches of Dorchester and South Boston. However, the proposal has not been implemented for reasons unknown.

c. The Water Quality Improvement Plan for Malibu and Tenean Beaches. This proposal was developed for the Massachusetts Division of Water Pollution Control in 1972, reference 5.71. It examined 25 alternatives proposed to abate pollution of these two major high-use bathing beach areas of Dorchester Bay. The alternatives fell into five basic groupings:

(1) Enclosure of beaches with disinfection of incoming beach waters.

(2) Separation of sewers.

(3) Relocation of combined sewer overflows by discharging into a conduit along the harbor which would feed into a proposed pump station of the "Old Harbor Pollution Control Program."

(4) Relocate combined sewer overflows by holding temporarily in tanks and slowly discharging to Deer Island treatment plant when flows can be accommodated.

(5) Treatment of overflows by disinfection, with and without solids removal.

The recommended program involved the concept outlined in group (3) and hence was contingent upon construction of the "Old Harbor Pollution Control Program" which was not implemented. Anticipating that possibility. the report recommended enclosure of the beaches as the second choice.

The recommendations of this report have not been implemented.

d. Alternative Regional Sewerage Systems Study for MAPC. This study examined the regional needs of the Boston Metropolitan Area, including some communities outside the MSD and SESD, reference 5.22. The report recommends a program including construction of nutrient removing treatment plants at Canton and Natick to provide flow augmentation to the Neponset and Sudsbury Rivers, respectively. Nut Island treatment plant would be upgraded and expanded to 150 MGD capacity. The report further discussed local alternatives for various drainage basins.

This study indirectly addresses itself to the combined sewer overflow problem by incorporation of various sewer relief conduits. The recommendations have not been implemented.

e. Water Quality Improvement Plan for the Boston Back Bay Fens. This program, developed for the Massachusetts Division of Water Pollution Control, by C. E. Maguire, Inc., recommended immediate rehabilitation of existing facilities, to separate sanitary sewage from the overflows to the Back Bay Fens. Dredging, aeration and flow augmentation was also recommended, reference 5.23. Some work was started November 1973 according to EMMA Volume 7. A second phase program was also recommended which would provide facilities for diverting, detaining and chlorinating overflows, plus provide for Charles River water circulation through the Fens. The second phase has not been implemented and its status is unknown.

f. Other Proposals. More recent studies address themselves to the combined sewer overflow problem in part, and some are incomplete or in the review stages. The EMMA Study has already been discussed in Chapter 3 of this report. The MAPC is presently involved in the Section 208 Areawide Waste Treatment Management Planning Study, yet to be published. A report to the MDC recently published entitled Non-Structural Controls for Combined Sewer Overflows prepared by Environmental Research & Technology, Inc., reference 5.24, examines the feasibility of controlling overflows by implementing a program of flushing the sewer system during dry weather periods. The study used the Boston Area, especially the Dorchester Bay region, as a case example. The study compared "the estimated costs, pollutant loadings reductions and receiving water quality resulting from the least costly structural alternative, detention and chlorination facilities," (reference page 31) against various levels of non-structural controls. The report concluded that non-structural control, to meet Massachusetts receiving water standards, would cost about 15 percent of the cost for equivalent performance by detention and chlorination facilities. The non-structural control would provide dry weather flushing and wet weather in-line storage. Data presented also indicated the O&M costs would be less. Implementation of such a non-structural program would require less time than equivalent structural proposals, it was reported. Sewage was proposed to be used for flushing.

Perhaps the presentation of new alternatives in some of the recent and current studies has led to apparent tabling of earlier proposals. Lack of financing and regional cooperation may have caused the demise of some programs. A number of possible technical solutions to both regional and local combined sewer overflow problems have not been implemented, despite the emphasis focused upon the importance of problem and apparent acknowledgement of the magnitude of the problem.

3. PRESENT PLANNED PROJECTS

Aside from some facilities upgrading and mechanical repair programs and a few sewer separation projects, only one significant overflow abatement project is currently under construction.

a. The Charles River Estuary Pollution Control Facility is to be constructed near the new Charles River Dam, now under construction. The facility was designed for the MDC to handle combined sewer overflows resulting for storms less than or equal to the 5-year storm which now discharge below the old dam but above the new dam, reference 5.25. The 5-year storm has a rainfall intensity of 0.47 inches per hour. The station is designed to intercept overflow from the Cambridge and Boston marginal conduits, the Msgr. O'Brien Hwy. Overflow, the Lowell Street Overflow from Boston and the Millers River Overflow from Cambridge and Charlestown. Combined sewer overflows of up to 323 MGD reportedly will receive treatment consisting of screening, settling, skimming and chlorination. The station's wet weather effluent will be piped to the Inner Harbor, just below the New Charles River Dam site through a 96-inch force main while settled material will be pumped through a 12-inch force main to a Deer Island Interceptor.

The station will include a dry weather pumping station within a wet weather treatment and pumping station. Except for the dry weather pumping feature, the facility will be similar to the Cottage Farm station.

The dry weather system will include a fine screen with 0.5-inch openings, a hammermill grinder, a Parshall flume and two pumps each rated at 1735 gpm peak capacity.

The storm flow system will contain three fine screens with 0.5-inch openings, a hammermill grinder, six detention tanks (1,188,000 gal. total capacity), and six overflow screens with 0.25-inch openings. Pumping will be by three engine driven 75,000 gpm pumps and one electric motor-driven 49,500 gpm variable-speed pump. Disinfection will use sodium hypochlorite, dosed at the influent to the tanks. Detention time in the tanks at design flow will be 5.5 minutes.

Standby power for plant operation will be provided by a diesel powered unit. A primary advantage of the new Charles River Pollution Control Facility is cited as its discharge location. As a result of the new Charles River Dam, now under construction by the Corps of Engineers, combined sewer overflows upstream of the new Dam would therefore affect water quality in the impoundment, as the Cottage Farm facility effluent now does in the existing impoundment. The new facility would allow interception of these overflow points with the combined sewage flows to be collected, "treated," and discharged below the Dam in the tidal waters of the Inner Harbor. This collection and diversion alone should improve the quality of the Charles River impoundment. As of the end of calendar year 1976, the construction of the New Charles River Station had been stalled due to contractual disagreements. Reportedly, the major drain pipes to and from the station are under construction. Completion of the Station itself hinges upon the outcome of contractual problems.

b. Other MDC Projects. As reported in Chapter 3, the EMMA Study recommends facilities planning for the following core area combined sewer overflow projects:

(1) Dorchester Bay Project,

(2) Charles River Project, including the Muddy River and the Back Bay Fens,

(3) Neponset River Project, and

(4) Boston Inner Harbor Project

These projects are planned to remove some amounts of solids, floating matter and other undefined pollutional discharges with the aim of achieving the objectives for water contact recreation, shell fishing, and aesthetic improvement. Cost estimates made in the EMMA Study were based on facilities similar to those at Cottage Farm, but sized to provide 15 minutes detention rather than 7 minutes detention at design flows. Unfortunately, effluent limitations that will be applied to future combined overflows are not known. Present EPA Regulations require secondary treatment of all sanitary sewage discharges but permit the Regional Administrator to allow deviations for combined sewer overflows on a "case-by-case" basis, based on best practicable technology and environmental effects. Authors of the EMMA Study agree that future water quality standards for combined sewer overflows will affect costs of facilities that must be provided in the Recommended Plan. The degree of treatment that will be required is not specifically designated in the Report since it has not been determined by the Regional Administrator.

None of the combined sewer overflow projects are included in the scope of the Environmental Impact Statement now being prepared for some of the facilities proposed in the EMMA Recommended Plan. We were advised that EPA plans to issue a Negative Declaration on the combined sewer overflow projects on the basis that the projects are needed and are not controversial.* The degree of treatment likewise is not considered controversial; it is just unknown. The fact is, however, that the scope and cost of the projects cannot be defined until standards are determined.

---

* (In 1978, EPA advises that this decision will be made after Facilities Planning is completed.)

c. Other Overflows. We know of no plans for reducing the overflows from existing sources not included in the EMMA Study. These problem areas are still undefined in the communities of Gloucester, Beverly, Danvers, Peabody, Salem, Lynn, Saugus, Revere, Stoneham, Everett, Medford, Malden, Waltham, Hingham, Norwood, and Milford.

4. SEPARATION OF COMBINED SEWERS

An obvious solution to the problem of combined sewer overflows is to separate the stormwater collection system from the sanitary sewer system. This, however, does not eliminate the pollution load of stormwater runoff. In nearly all cases, this alternative has been considered in the various proposals historically brought forth concerning overflow abatement in the Boston Area. Sewer separation proposals vary from regional plans to local only; from partial system separations to total separation including building plumbing separation.

Certain local areas have found the separation of sewers to be their most cost-effective option in solving their overflow problems. Some areas, therefore, have been or will be undertaking combined sewer separation. The Town of Brookline has already carried out separation in a majority of its community. The City of Cambridge is undertaking separation in parts of the community which are not presently tributary to the Cottage Farm Facilities. As a part of its urban renewal program, Boston is separating sewers in some areas, including Charlestown.

A 1974 report on "Improvements to the Sewer System" made for the City of Somerville recommended partial separation of the combined sewer system as the cost-effective solution to the overflow problems in certain areas of the City, reference 5.26. The Massachusetts Division of Water Pollution Control has approved the report. The NPDES Quarterly Non-Compliance Report dated September 14, 1976, indicates implementation of the recommendations has been delayed, reference 5.27. The reported reason for delay was:

> "Question on Federal funding just resolved. HUD to pay permittee's share."

While sewer separation is considered the ultimate solution in certain instances, it has been considered a poor alternative in many other cases. In Boston every street would have to be ripped up and every building would have to be repiped to accomplish the separation of sanitary waste plumbing from roof and other stormwater plumbing. The costs to renovate private property would be prohibitive and it is felt that the short-term impacts would be intolerable.

The EMMA Study noted that:

> "Not only is it expensive, it could cost up to $1.7 billion to completely separate sewers in this metropolitan area, but it is physically not feasible in many cases such as downtown Boston. In addition...the pollution content of stormwater itself makes the quality improvements achieved by separation not comparable to the investment necessary to accomplish separation." Reference 5.10, page 4-8.

The present policy concerning combined sewer separation in the Boston Area seems to be that it is an alternative best suited to only certain local areas. Such areas are usually remote non-downtown areas where less physical inconvenience would occur and where consolidation of widely separated overflows is expensive,

The use of sewer separation as a solution to combined sewer overflows is more effective in reduction of coliform levels (and especially pathogen levels) than in reducing BOD and suspended solids pollution where the stormwaters are discharged without treatment into the same receiving waters which once received combined sewer overflows. As noted in the description of runoff quality, the pollutional impact of storm runoff flows upon the receiving waters can be significant. The success as well as the expense of sewer separation projects must also be measured against the degree of water quality improvement in the receiving waters.

D. ANALYSIS OF EXISTING OVERFLOW STATIONS

Two combined sewer overflow stations have been built in the Boston Area. Both were funded in part by EPA demonstration grants pursuant to PL 92-500, Section 105 "grants for Research and Development." In fulfillment of the grants, reports on the operation of the facilities have been drafted but not published. Based upon these reports and upon recent data gathering, the operational efficiencies of the two facilities are examined herein. Excluded from detailed consideration are the overflow diversion facilities existing at Calf Pasture and Moon Island and at the East Boston pump stations.

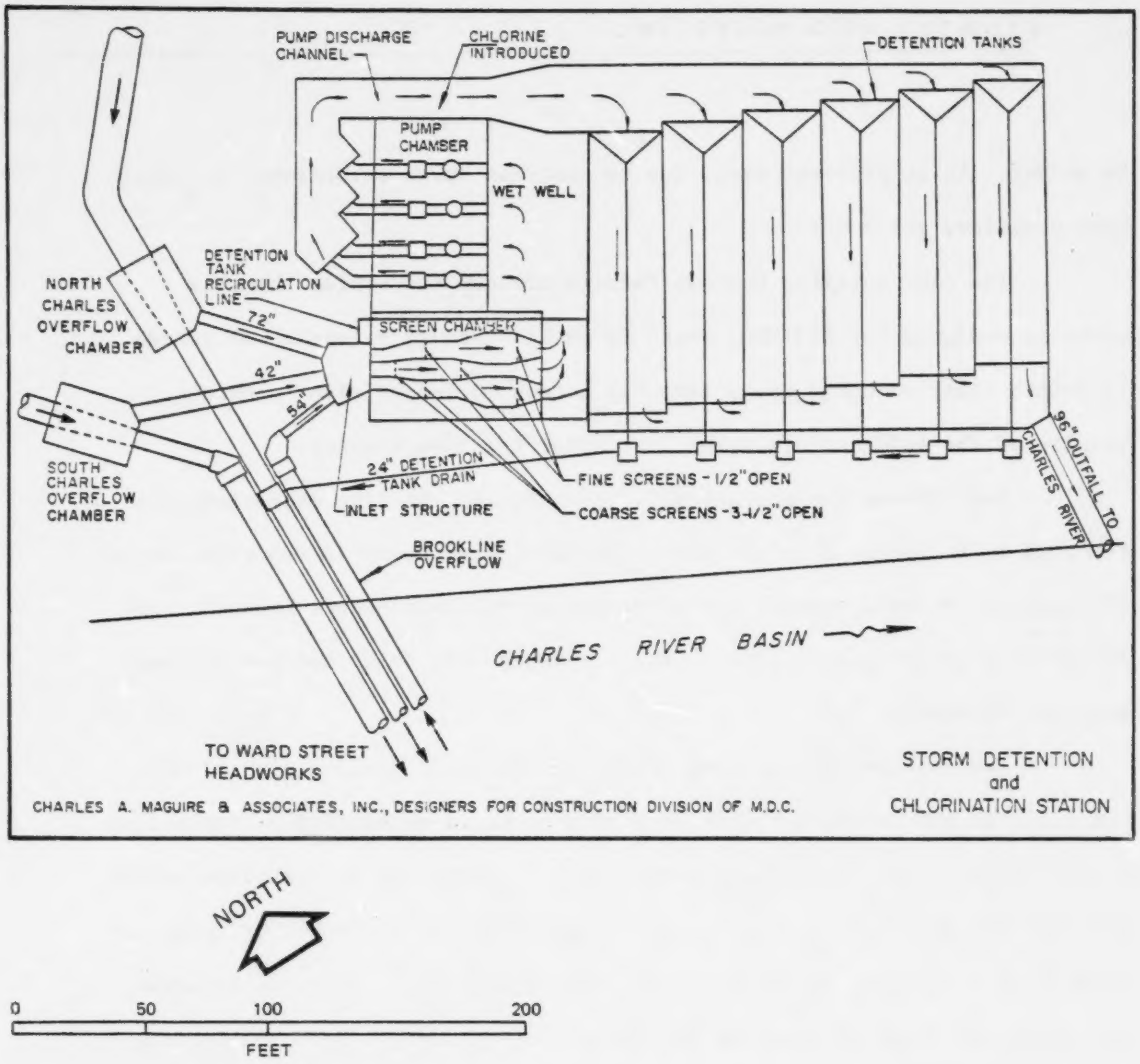
Continuation of the use of the existing Calf Pasture pumping stations and Moon Island holding tanks were considered in the EMMA Study but are not included as a part of the EMMA Recommended Plan for future use. Our visits to these archaic facilities indicate that they both are severely deteriorated and must be considered unreliable in operation. We were advised that there are leaks in the Calf Pasture force main and in the Moon Island outfall. The facilities are clearly unsafe to operate and unsatisfactory according to modern practice. We confirm that use of these for wastewater service should be discontinued as soon as possible. In particular, access to the operating gates on the holding basins at Moon Island is over rotted wood platforms. The condition of the manual gate operators is such that it is probably physically impossible, on occasion, to utilize the holding tanks to restrict discharge to ebb tide periods.

1. COTTAGE FARM STORM DETENTION AND CHLORINATION STATION

The Cottage Farm Storm detention and Chlorination Station was constructed with the aid of a Federal Water Quality Administration (FWQA) Demonstration Grant No. 11020 FAT in the amount of $1,000,000. Operation was begun in 1971 under the auspices of the MDC. A report has been prepared for EPA (successor to FWQA) in fulfillment of that grant, detailing the first three years of operation. In addition to personal observation, much of the data and information on the facility comes from that report, reference 5.28. During the test period the facility did not have planned tributary connections. When construction of the Brookline connection is completed, an estimated additional peak flow of 70 MGD will be tributary to the facilities. It is also reported that connection of additional tributary flow into the North Charles Relief Sewer will be made which will further increase peak flows.

a. Description of the Facility. The Cottage Farm Station, as shown on Figure 5-2, was designed to be activated when flows in the North and South Charles Relief Sewers of the MDC system exceed 146 MGD. It can also be activated when the Ward Street headworks inflow is throttled. Inflow to the facility is controlled by slide gates. These gates are normally in a closed position. There is provision for automatically opening the gates when liquid level in the inlet structure exceeds 14 inches. At the time of the site visit, gates were in a manual operation mode.

No analysis was found which detailed whether overflows still occur when the Cottage Farm facility is operating, or before inlet level reaches


PUMP DISCHARGE CHANNEL
CHLORINE INTRODUCED
DETENTION TANKS
PUMP CHAMBER
WET WELL
DETENTION TANK RECIRCULATION LINE
NORTH CHARLES OVERFLOW CHAMBER
72"
42"
54"
SCREEN CHAMBER
SOUTH CHARLES OVERFLOW CHAMBER
24" DETENTION TANK DRAIN
INLET STRUCTURE
FINE SCREENS - 1/2" OPEN
COARSE SCREENS - 3-1/2" OPEN
96" OUTFALL TO CHARLES RIVER
BROOKLINE OVERFLOW
CHARLES RIVER BASIN
TO WARD STREET HEADWORKS
STORM DETENTION and CHLORINATION STATION
CHARLES A. MAGUIRE & ASSOCIATES, INC., DESIGNERS FOR CONSTRUCTION DIVISION OF M.D.C.
NORTH
0
50
100
200
FEET

Rated Design Capacity: 233.1 mgd

FY 75-76 Average Flow per Activation: 13.6 million gallons

NSF Boston Case Study, Phase II Evaluation

PLAN OF
COTTAGE FARM STATION

Kennedy Engineers, Inc. Figure **5·2**
1977

Source: Plan from Ref. 5.28

14 inches. It is probable that, due to upstream sewer surcharges, at least some overflows still occur.

The flow entering Cottage Farm is divided into three channels (each is designed for 120 MGD) where it passes through a coarse bar screen (3.5-inch clear opening) and a fine bar screen (0.5-inch clear opening). Samples of the influent are taken just after the fine screens.

The screens are mechanically cleaned, and the fine screenings are reported to be returned to the North Charles Relief Sewer (along with 400 to 1600 gpm of screened sewage) for treatment at the Ward Street Headworks and at the Deer Island plant. The coarse screenings are collected and trucked away for disposal.

The combined sewage then enters the Wet Well (volume of 0.35 MG). Pumping from the Wet Well to the detention tanks is automatically controlled by the height of the liquid in the Wet Well. Activation of the pumps beings when the liquid volume in the Wet Well exceeds 0.145 MG. The first pump activated is a 30-inch, 40 MGD electric motor-driven pump. This is followed, if needed, by three 42-inch, 86 MGD diesel-driven pumps. Up to 90 percent of the design flow of the station (233 MGD) can be handled with any one of the pumps inoperative. The discharge of each of the four pumps is metered.

Sodium hypochlorite is fed into the flow from each pump by feeders at dosage rates ranging from 2 to 4 milligrams per liter of available chlorine.

From the pump discharge channel, the flow is separated into six channels which feed into the six baffled detention tanks. Although the channels are fitted with stop-log grooves so that unneeded tanks may be isolated, stop logs are not used due to the need for flexibility during storm events. The total capacity of the detention basins is 1,200,000 gallons, which provides 7.4 minutes theoretical detention at design flow.

The tank overflows under a baffle and upwards through horizontal hinged panels of wire mesh screens (0.2 inch openings). The trapped solids are washed off after each activation. When the screens become clogged, which occurs in less than an hour at low flows and in minutes at high flows, they are designed to swing up parallel to flow which then flushes any accumulations into the effluent. Sampling pumps withdraw samples of the effluent ahead of the fine mesh screens.

After each facility operation, the detention tanks are emptied through bottom drains, with the contents then flushed back to the North Charles Relief Sewer. The Wet Well is dewatered by pumping dry.

b. Performance of Cottage Farm Station. The MDC report on the first 38 months of operation of Cottage Farm states that the facility was activated an average of 36 times per year. The original design was based on 22 activations per year. Excess flows at the station are believed to have been due to:

(1) Abnormally high rainfalls during 1972, and

(2) Increased incidences of interceptor sewer back-ups due to throtting inflow to Ward Street Headworks.

The Report states that the duration of activations ranged from 30 minutes to 43 hours. The average flow to the facility was 6.7 million gallons per activation, with most activations lasting less than 13 hours.

Only those flows in excess of the combined volume of the six detention tanks (1.2 MG) and the Wet Well (0.1 MG) overflowed to the Charles River. Although no metering of the overflow to the river is provided, an estimate was made by subtracting the estimated volume remaining in the detention tanks (maximum of 1.2 MG) from the volume pumped from the wet well.

Reported efficiency and performance data on the facility can not be accepted because of deficiencies in sampling techniques, lack of effluent flow measurement, use of assumed values in computing averages, omission of certain data, and inclusion of data on flows not producing a discharge. The data shows the plant has never operated at rates above 40% of rated capacity.

It was reported during the site visit that for less than half of the inflow occurrences there was not any effluent discharged. The operation of the detention basins during those small events prevented a significant amount of overflow to the Charles River. The effectiveness of the station as a chlorination/treatment facility, however, is subject to serious question.

Considerable investigation has been performed on disinfection of raw sewage, particularly in the 1930's. The general conclusions were that it is difficult if not impossible to achieve and can only be obtained by removal of large solids, grease, scum and other floating matter and when the dosage rate is adjusted for the strength of the sewage. Dosage rates ranged from 20 to 100 mg/l and detention times needed were in the range of one hour.

Chlorination at the Cottage Farm facility has a number of deficiencies. Because the hypochlorite solution is injected into the pump discharge pipelines, there is no assurance of immediate dispersion and diffusion.

Because of the basin inlet characteristics, it is probable that, especially under high flow conditions with high velocity gradients, sheet flow exists and actual detention is a fraction of theoretical detention. There appear to have been no tracer studies to determine actual detention times and T_i at various flow rates.

In addition, because no surface skimming is provided, floating solids, grease and scum will be virtually unaffected by the chlorine in the water and float across the basin and discharge with the effluent.

Raw sewage chlorine demand before disinfection starts ranges from 4 to 10 mg/l. The dosage of 2 to 4 mg/l can not be considered adequate for disinfection. Even if the reported coliform reductions ranging from 43 to 99 percent are actually accomplished, the effluent would still contain coliform levels of several million per 100 ml.* This is considerably in excess of the 1000/100 ml which will be imposed by the NPDES permit for deep outfall disposal of effluent from the Deer Island secondary treatment plant.

Studies have indicated that for combined sewer overflows, normally the first discharge is almost entirely sanitary sewage. The strength then drops as dilution occurs. As flows increase and resuspension velocities are reached in the large sewers, wastewater strength increases and may continue at high levels for several hours, depending upon the amount of solids accumulation in the sewers.

It is probable that the Cottage Farm facility usually provides significant removals on the first discharge when detention time approaches that of normal primary sedimentation. It is also probable that removals at

* See note on page 5.100

high flows are minimal. In fact, it is probable for prolonged operation (which has been as long as 43 hours), organic solids are resuspended off the floor due to septic action and are discharged with the effluent. Because discharge from the facility is to the Charles River Dam impoundment, this pollution load adversely affects its water quality.

The MDC report on operation of the Cottage Farm facility is misleading in that some data are based on estimates. In computing performance, no distinction was made between inflows that result in overflows to the river, inflows that are entirely contained by the detention tanks, and those that result in a major portion of the inflow being contained by the detention tanks. While it is proper to include, as reduced loading to the receiving waters, the flows wholly or partly contained by the detention tanks, they are not properly included in calculating the treatment efficiency of the facility.

Treatment efficiency should be calculated on the basis of effluent flow rates and removals at low flow rates should not have been averaged with removals at high flow rates. Since there are no provisions for effluent flow metering, this will be difficult to do. It should also be noted that no flow rates during the test period approached the stated design capacity of the facility.

c. Operational Aspects of Cottage Farm. The MDC report on the three years of operation briefly discussed the operational problems as well as the effectiveness of various mechanical components of the facility. These and personal observations are discussed below:

(1) Screening. The facility has three sets of screens: coarse bar screens, fine bar screens, and the ineffective wire mesh screens on the

effluent. MDC has suggested removal of the coarse bar screens, presumably to eliminate the cost of operation and maintenance.

MDC reported that 615 cubic feet of screenings were removed per year by the fine screens and returned to the sewer flowing to Deer Island.

(2) Chlorination. The automatic chlorine feeder and residual chlorine analyzer/indicator/controller are out of service due to equipment damage from chlorine solution leaks. It is also reported that the hydochlorite generator malfunctioned.

(3) Pumping Equipment. While the electrically driven pumps operated very reliably, the diesel pumps have given problems which are complicated by the fact that flow cannot be diverted to the station to check pump operation and exercise the equipment during dry weather.

(4) Operation Manual. No operation and maintenance manual was reported available to personnel on the site.

Laboratory analyses are performed but performance data are not made available to personnel on the site.

(5) It was reported that on one occasion, the Cottage Farm facility operation had to be terminated because high water in the Charles River caused backup into the plant. If this is true, it could be a serious constraint on usefulness during high rainfall events.

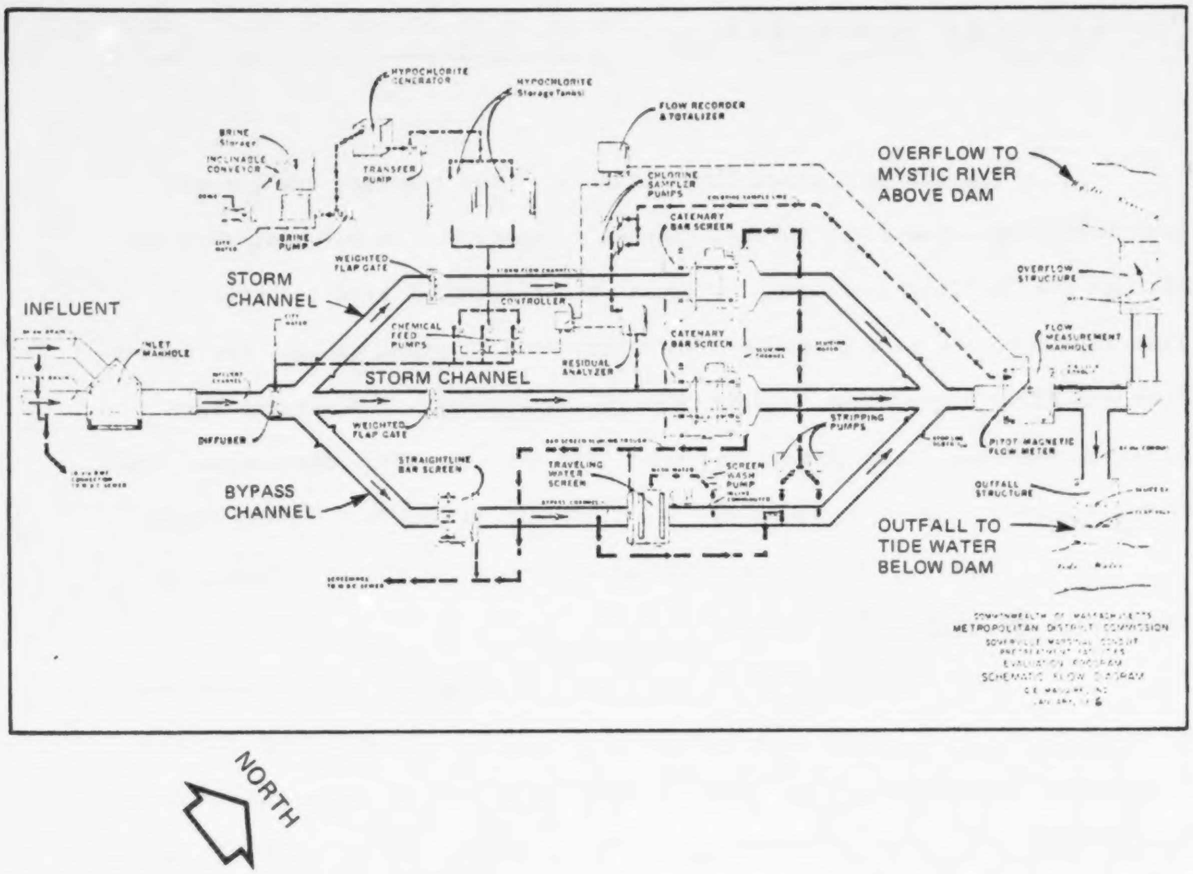
Based in part on a directive posted at Cottage Farm calling for reduction of operating costs and manpower, there is an indication that the Cottage Farm facility may not always be operated during minor or short-term sewer surcharges due to the cost of manpower to clean up detention tanks and equipment after an activation.

2. SOMERVILLE PRETREATMENT FACILITY

The Somerville Pretreatment Facility was constructed in 1972 with the aid of Federal Water Quality Control Administration Demonstration Grant 11023-DME. Testing of the facility began in mid-1973 by the MDC. A preliminary draft copy of a report on the initial operation has recently been made available. A final report is due to be submitted to EPA in fulfillment of the demonstration grant. The draft report provided most of the information presented in this section, reference 5.30.

a. Description of the Facilities. Flow to the Somerville facility, as shown on Figure 5-3, is from two large conduits which formerly discharged directly into the Mystic River just above the new Amelia Earhart Dam. An 18-inch pipe has been provided ahead of the station to convey dry-weather flows from the station influent interceptors back to the MDC combined sewer. Dry weather flow, however, enters the facility when flows exceed the capacity of the 18-inch line, or when the 18-inch line becomes plugged.

All the dry weather flow which enters the facilities, plus the initial small storm flows are diverted to a by-pass channel. This channel is the smallest of the three parallel channels in the facility. Flows through this channel pass through a straight-line bar screen (2-1/2-inch clear openings between bars) and then a traveling water screen (3/16-inch openings in mesh). Debris from the bar screen is raked into a hopper and manually removed. The screenings from the traveling water screen are reported to be discharged to a MDC sewer tributary to the Chelsea Creek headworks and Deer Island.


HYPOCHLORITE GENERATOR
HYPOCHLORITE Storage Tanks
BRINE Storage
INCLINABLE CONVEYOR
BRINE PUMP
TRANSFER PUMP
FLOW RECORDER & TOTALIZER
CHLORINE SAMPLER PUMPS
CHLORINE SAMPLE LINE
CATENARY BAR SCREEN
OVERFLOW TO MYSTIC RIVER ABOVE DAM
WEIGHTED FLAP GATE
STORM CHANNEL
INFLUENT
INLET MANHOLE
CONTROLLER
CHEMICAL FEED PUMPS
CITY WATER
RESIDUAL ANALYZER
CATENARY BAR SCREEN
OVERFLOW STRUCTURE
FLOW MEASUREMENT MANHOLE
STORM CHANNEL
DIFFUSER
WEIGHTED FLAP GATE
STRIPPING PUMPS
PITOT MAGNETIC FLOW METER
STRAIGHTLINE BAR SCREEN
TRAVELING WATER SCREEN
SCREEN WASH PUMP
BYPASS CHANNEL
OUTFALL STRUCTURE
OUTFALL TO TIDE WATER BELOW DAM
COMMONWEALTH OF MASSACHUSETTS
METROPOLITAN DISTRICT COMMISSION
SOMERVILLE MARGINAL CONDUIT
PRETREATMENT FACILITIES
EVALUATION PROGRAM
SCHEMATIC FLOW DIAGRAM
C.E. MAGUIRE, INC.
JANUARY, 1976
NORTH

SCHEMATIC – NOT TO SCALE

Rated Design Capacity: 540 cfs = 349 mgd per Ref. 5.30
160 mgd per EMMA MAIN REPORT, page 5-3
No data on actual flows

NSF Boston Case Study, Phase II Evaluation

PLAN OF SOMERVILLE STATION

Kennedy Engineers, Inc. 1977

Figure **5·3**

Source: Plan from Ref. 5.30

The two main storm flow channels of the facility are for use only when flows exceed the by-pass channel's capacity. As wet-weather flow through the facility increases, it causes a differential head to occur on flap valves to the main channels. When this head is great enough, the valves open and allow storm water to pass through bar screens. The screens have 1/2-inch openings. The screens are raked and the screenings discharged from a collection trough to an MDC sewer for treatment at the Deer Island plant.

Cleaning of the traveling water screen and the bar screens is controlled automatically.

Chlorination of the flow through the facility is by dosing with sodium hypochlorite, which is generated at the site. The generator utilizes a saturated salt brine and electrolytrically produces the sodium hypochlorite. The hypochlorite is fed to the flow through a diffuser in the Influent Channel by three chemical feed pumps. During dry weather flow conditions a set dosage of hypochlorite is supposed to be injected. During wet weather flow conditions, the hypochlorite injection is designed to be paced by a magnetic flow meter which measures the effluent flow 60 feet downstream from the facility.

Following pretreatment, the flow is transported through 2,120 feet of 7'-6" x 11'-0' conduit and 2520 feet of 84-inch diameter pipe to an outfall structure located below the Amelia Earhart Dam on the Mystic River. The only chlorine contact time is that provided within the conduit system. The outfall contains a flap gate to avoid tidal backflow and a slide gate to provide closure of the discharge to prevent backflow during high tides.

When flows and tides are such that the outfall flap gate will not open or open sufficiently, flows from the facility then overflow to the Mystic River above the Amelia Earhart Dam via an overflow structure. Overflow is controlled by a fixed weir. The overflow structure is located at the transition between the two conduit sizes, approximately 2,120 feet downstream of the facility.

The preliminary draft report indicates that the Somerville Pretreatment facilities were designed to handle the combined sewer flood caused by a storm occurring every 25 years (25-year design storm) in the drainage area served. This was computed as 540 cfs or about 349 MGD. No indication was given, however, as to whether this capacity is provided for all facilities or only relates to the hydraulic capacity of the structures. Moreover, volume 7 of the EMMA Report indicates the "Somerville Pretreatment Facilities are designed to treat about 160 MGD...," reference 5.10, pg. 4-3. Therefore, a large discrepancy exists between the reported capacity of the facilities.

A major effect of the space constraints reportedly placed on the facility's design was that chlorine contact time is provided for only in the discharge conduit. There are no detention tanks as at the Cottage Farm Station. During peak flow (using the rated value of 349 MGD) and discharge at Outfall Structure, the chlorine contact time provided in the conduit is approximately 9 minutes. When the discharge occurs at the Overflow Structure the contact time is less than 5 minutes. During low flow conditions, chlorine contact time will be long than 9 minutes.

b. Performance of Somerville Pretreatment Facility. Although the Somerville facility has been operating since mid-1973, the facility is still under the management of the Construction Division of the MDC. As of November 1976, the operations have not been turned over to the Operation and Maintenance Division. The reason for this condition is reported to be the poor performance of the facilities.

The preliminary draft report on the performance of the Somerville Pretreatment facility intended to evaluate treatment efficiencies of the various components of the facility and to evaluate pollutional impacts upon the Mystic River Basin before and after the plant was operational. A pre-construction program of water quality sampling was carried out. However, the planned post-construction sampling program were never undertaken because of "unsolveable" operational difficulties encountered with the facility. As a result, the preliminary draft report provides no analytical data on BOD, solids, or coliform cconcentrations in the influent or effluent. No evaluation of performance relative to treatment efficiency is possible.

It was reported that "dry weather flow is usually sufficient to keep a flow through the system at all times." This would indicate continuous activation of the facility, even during dry weather. It therefore serves as a continuous raw sewage by-pass from the Deer Island plant to the Mystic River estuary.

As in the case of the Charles River Estuary Pollution Control Facility under construction, discussed earlier in this chapter, a primary feature of the Somerville facility is that it diverts the overflow discharge from the Mystic River basin to the tidal estuary below the Dam. Unfortunately, at Somerville the elevations of the plant require an overflow structure of its own which discharges into the basin above the Dam. The elevation problems are reported to be the result of an error during construction, as the top of the overflow weir was built 1.3 feet lower than designed. The weir elevation has not been changed, because it is reported that the problems of surcharge within the Somerville trunk sewer system will be better relieved by this condition.

c. Operational Aspects of Somerville Facilities. A major portion of the preliminary draft report on the Somerville Pretreatment Facility covered the operational difficulties encountered during and following start-up.

The preliminary draft states that:

> "At present the facility is operating using only the storm flow channels and a bulk rate dosage of chlorine. It is expected that this this is all this facility can be expected to do without the expenditure of considerable time and money."

and that:

> "The facility, as originally envisioned, is unsuitable for other similar situations at this time."

Under these operating conditions, the effectiveness of the chlorination system is limited. The facility was intended to operate by having the organic solids break down into small particles as they were forced through the traveling water screens. If the organic matter is not broken into infinitesimally small particles, it is not possible for the chlorine disinfectant to attack the attached and enclosed bacteria. The primary problems encountered in operating the Somerville Pretreatment Facility can be attributed to higher concentrations of grit, sludge and debris than the equipment could handle. Since these materials are typically present in combined sewer flows, the system, as it is, is incapable of providing the necessary pretreatment. The operational problems are directly related to features incorporated in the design. Space and money allocation for this project was reported as insufficient to provide the necessary facilities for proper removal of grit, sludge and debris. As a result, disinfection of the flows is limited in effectiveness also.

The report concludes:

> "The foremost conclusion which can be drawn from the Somerville Pretreatment Facility is that this inexpensive approach to combined sewage treatment is, at this time, inappropriate."

3. COST ANALYSES OF COMBINED SEWER OVERFLOW FACILITIES

The three so-called combined sewer overflow treatment facilities of the MDC differ greatly in their sizes, capacities, "treatment" features and associated construction and operating costs. Allowance must be made for these differences in any cost comparisons made.

The Cottage Farm Detention and Chlorination Station was constructed to treat up to 233 MGD at a cost of about $4,850,000 (1971 dollars, ENR Boston of 1700). This figure includes the stations's 96-inch diameter outfall. The Federal Water Quality Administration (now in the EPA) provided a $1,000,000 demonstration grant to this project. Relief sewers required to transport the combined sewer overflows to the Station were constructed or are being constructed at a cost in excess of $8,000,000, reference 5.28. Therefore, costs associated with transport, pumping, screening, detention and chlorination at Cottage Farm were about $13,000,000 (in 1971-1974 dollars). This would be equivalent to $16,000,000 at ENR cost level of 2200.

Operation and maintenance costs for the Cottage Farm Station were estimated at $81,500 per year, using June 1974 price information. For the period covered in the Cottage Farm Report, the unit cost per million gallons diverted to the Station was about $293. This estimate included chemical, energy and personnel costs, of which two-thirds was personnel costs, reference 5.28.

The Somerville Pretreatment Facility is unlike any other in the area. Because it provides no detention and provides no pumping of the combined sewage flow, construction and operating costs are consequently smaller than those of Cottage Farm. The two conflicting capacities reported for the Somerville Facility are 160 MGD and 349 MGD. The draft report on the Somerville Pretreatment Facilities indicated that the total annual cost of Cottage Farm was about 4-1/2 times that of the Somerville Facilities. The reported annual operation and maintenance cost was given as $19,000. (It was not reported what year or years this covered, nor the price index used). Based upon this information and that of the Cottage Farm Report, Table 5-1 provides a cost comparative approximation for the two facilities. Unfortunately, it is unknown whether the construction cost for the Somerville Facility included the transport system to the Facility and the discharge conduit.

TABLE 5-1

COSTS OF COMBINED SEWER OVERFLOW FACILITIES

	Somerville Facility	Cottage Farm Facility
Historic Construction Cost	$1,040,000	$4,850,000
Amortized Capital Cost*	$ 69,000	$ 322,000
Annual Operation and Maintenance	$ 19,000	$ 81,000
Total Annual Cost	$ 88,000	$ 403,000
Rated Capacity, MGD	160-349	233
Year Built	1972	1970

*Amortization is for 40 years @ 6%

Data from References 5.28 and 5.30.

It is assumed that the table only compares the treatment portions of the two projects. There is no way to compare the "treatment" performance of the two facilities as they both provide minimal effluent quality improvements.

Operation and maintenance costs per million gallons diverted to the Somerville Facility can not be computed as flow data are not available.

The new Charles River Estuary Pollution Control Facilities (rated at up to 323 MGD) consists of three major components, interceptors, the station, and outfalls.

The Detention, Chlorination and Pumping Station was reportedly bid at $12,300,000 in 1976, reference 5.30. The report on the new facilities provided the following estimate of the construction and project costs of the Facilities in 1972, reference 5.25:

Item	Construction Cost	Project Cost
Interceptor Sewer System	$ 3,453,000	$ 3,798,000
Detention, Chlorination and Pumping Station	9,372,000	10,309,000
Outfall Force Main	1,981,000	2,179,000
	$14,806,000	$16,286,000

An application for a grant was submitted to the EPA for this project and a grant was awarded in May 1975. EPA Grant No. C250312-01 indicates the following approved allowable cost budget for the project:

Administrative Expense	$ 7,000.00
Arch./Engineering Fees	$ 1,053,312.05
Other A/E Fees	$ 603,268.40
Construction & Project Improvement Costs	$21,066,241.00
Contingencies	$ 2,470,178.55
Total	$25,200,000.00

The approved grant amount was 75% of the total, or $18,900,000. While this is listed as a Step 3 grant, it is believed that it covers costs for Steps 1, 2 and 3 of the project.

The Cottage Farm Station and the new Charles River facilities are of comparable design and are typical of the proposed detention-chlorination stations offered under some of the alternatives in various studies of the combined sewer overflow problem in the study area. Because the two facilities provide similar treatment and transport features, it is possible to examine the approximate cost of combined sewer overflow facility construction per million gallons of rated treatment capacity.

The Cottage Farm Station cost about $21,000 per million gallons rated capacity at 1971 prices. The Charles River Estuary Detention Chlorination and Pumping Station was estimated to cost about $29,000 per million gallons rated capacity in 1972. The 1976 bid price for the construction of the station was at $38,000 per million gallons rated capacity. The estimate for the entire Charles River Facilities Project (including transport systems) in 1972 was $45,000 per million gallons. The comparable cost at 1976 prices was about $59,000 per million gallons of capacity.

4. IMPACT OF TREATMENT FACILITIES ON THE OVERFLOW PROBLEM

Before the passage of PL 92-500, much planning had been performed but very little construction had been implemented to alleviate the problem of combined sewer overflows in Boston Harbor and its tributaries even though it was considered the major water quality problem. After passage of PL 92-500, only limited effort and money has been applied to the overflow problem. The Federal Government has provided grants to a few communities for partial sewer separation. Two demonstration grants were awarded to the MDC to aid in investigating the feasibility of "treating" combined sewer overflows at Cottage Farm and Somerville. The new Charles River Estuary Pollution Control Facilities Project was the first project for combined sewer overflow pollution abatement in the Boston Area for which the EPA has provided a major construction grant (75% of estimated project cost).

The new NPDES permit effective September 1976 (as modified by the ECSL) stipulates that future combined sewer overflow projects provide capacity for flows from 1-year storms of 6-hour duration. Screening, chlorination and detention is the mandated solution, even though such facilities have not been demonstrated to provide effective treatment or water quality protection. The minimum chlorine content of the flow at the point of discharge is required to be 1.0 ppm.

While mandating the above process requirements for the future facilities, no effluent quality or quantity limits have been given by the EPA through the permit system which would define the reduction in pollution from combined sewer overflows. Neither are the points of discharge given. The screening requirement does not define the type or size of openings, nor does the detention requirement define the size of detention basin or the duration of chlorine contact. *

It is believed that NPDES permits should not mandate even the process to be used but should specify effluent quality and point of discharge. The present policy of EPA indicated by acceptance of the EMMA Report, seems to be for local disposal of combined sewer overflows, with no effluent quality limitations.

The present combined sewage overflow "treatment" facilities provide only limited improvement of combined sewer overflows. In the core area alone, a 8,400 MGD overflow rate is estimated to occur from a 1-year storm of 6-hours duration, according to the EMMA Study. If Cottage Farm operated at its peak rated capacity of 233 MGD it would handle only about 2.8% of these overflows. If the Station were 15% effective in solids and BOD removals, then its impact upon the total pollutional load is only 1/2 percent reduction. On the other hand, during small storms, Cottage Farm detention capacity can eliminate overflows totally and return them to Deer Island for treatment. Under these conditions its impact is greater.

The Cottage Farm facility is designed to handle one thirty-sixth of the total estimated overflows of 8,400 MGD. If allowing more than 85 percent of pollutants to remain in the discharge is acceptable, overflows could be "treated" by 30 such plants at an estimated cost of $324 million.

---

* (EPA advises in 1978 that the permit language was too restrictive and that MDC has been allowed to examine alternatives in their formal Step 1 work.)

Since all plants could probably not be of the same scale, the cost would probably be more. In addition, collector sewers and relief sewers would be required to intercept present overflows and concentrate them at treatment locations. The EMMA Study projected only $270 million to abate combined sewer overflow pollution in its study area.

Clearly, treatment of an intermittent, widely varying flow with high waste loadings is difficult. It precludes the use of biological treatment. Water quality studies of the various receiving waters should be made to determine the degree of treatment necessary to achieve adequate water quality protection.

5. ALTERNATIVE OVERFLOW TREATMENT

No proven installations providing satisfactory treatment of storm water overflows using less than primary treatment are known. However, recent demonstration projects indicate there may be viable alternatives.

An obvious solution that has been used at many locations has been to increase collection and transport capacity to convey overflows to the treatment plant where primary treatment and disinfection are provided and effluent is disposed of in less sensitive areas. This may not be cost-effective to accomplish completely in the Boston area but considerable reduction in overflows could be accomplished by increasing tunnel headworks capacity, increasing primary treatment capacity and increasing Deer Island pumping capacity as discussed in Chapter 2. Excess flow should bypass the secondary treatment process during such events. Relief sewers (as required for detention/chlorination facilities) would also be required to eliminate overflows by upstream sewer surcharges.

Physical-chemical treatment of overflows has been installed in some locations but has not yet been demonstrated to accomplish satisfactory efficiency of pollutant removal and may not be cost-effective.

Swirl concentrators appear to have considerable potential. Plant scale installations have indicated removals comparable to primary treatment. They have an advantage of small space requirements. Because the removal efficiency of swirl concentrators reduces rapidly below half of rated capacity, parallel units are indicated to maintain efficiency.

Moving fine screens, similar to those used in the by-pass channel at the Somerville facility are effective in reducing pollution load, particularly those materials resistant to chlorine disinfection. Installed downstream of a detention basin they would avoid most of the operation problems experienced at Somerville. A demonstration project for installation of such fine screens following the detention basins at Cottage Farm could show significant removal efficiency. The effectiveness of disinfection by chlorination is dependent upon chlorine concentration, speed and uniformity of chlorine dispersion and diffusion, mixing, and contact time. It is also affected by pH, temperature and the form that the chlorine is in and the form of the material to be disinfected. Chloramines and chlorine addition compounds are slower in action than free chlorine. Also, chlorine cannot attack bacteria enclosed in particulate matter or bacteria in scum, grease, or in solids floating on the water surface. These considerations appear to have been ignored for the chlorination facilities installed by MDC.

Studies have indicated that raw sewage cannot be reliably and effectively disinfected. In order to obtain significant coliform reduction, dosage of 50 to 100 mg/l and contact for one hour or more is recommended. Very fine screening allows dosage reduction by about one-half and contact times similarly halved with more consistent results.

A recent development using high-speed rotating chlorine diffusers has indicated greatly increased disinfection efficiency with very short detention times, but is not applicable to raw sewage. This process, if proved in full scale operation, could provide disinfection of primary treated peak flows as well as effluent from physical-chemical or swirl concentrator treatment with minimal contact time and significant cost savings.

Based on our review of the detention stations, we believe they have demonstrated that removals of pollutants will be less than what is considered primary treatment when operated at design capacity.

E. SUMMARY OF CHAPTER 5

1. A local assessment of combined sewer overflow problems for the study area has not been found to have been completed. In the Metropolitan Sewerage District there are thirty-seven and one-half square miles, with a population of 900,000 persons, in the older portions of the core-area communities of Boston, Brookline, Cambridge, Chelsea and Somerville with combined sewers for sanitary sewage and stormwater. During dry weather, the flows are intercepted by the Metropolitan Sewerage District facilities and normally given primary treatment at Deer Island. During any significant rain storm, the combined sewage still overflows from several hundred points to the nearest watercourse. Overflows occur not only from the sewers of the communities with combined sewers and from the MSD interceptors but also from sanitary sewers of upstream communities. Several peripheral area communities also have combined sewage overflow problems.*

2. In the communities with combined stormwater and sanitary sewage systems, combined sewage is generated every time it rains, about once every three to five days. There is nearly the same amount of precipitation every month of the year in the study area.

3. The quality and quantity of combined sewage is highly variable. Combined sewage often has about the same BOD as sanitary sewage, with suspended solids over ten times higher than sanitary sewage. Objectional constituents, including toxic substances, vary with the time between storms. In addition, combined sewage is very difficult to handle or treat due to rapid flow variations and massive quantities of debris, grit, and floatables,

---

* (EPA advises that a $5 million Step 1 Study for CSO Control was initiated in June 1978.)

constituents not usually measured in normal sampling techniques.

The sewage treatment systems of the Metropolitan Sewerage District were designed for peak-to-average ratios of about two to one while intermittent combined sewer flows often exceed twenty to one.

4. Efforts to solve pollution problems by construction of sewage treatment plants have not been successful because there is inadequate capacity in the transport system to convey unregulated peak flows to the plants. Facilities allowing wet-weather overflows from combined sewer systems to waterways were built and are still necessary to reduce the flooding of streets and backup into homes. The location of such overflows has been reported as the major factor preventing Boston Harbor and its impoundments and estuaries from meeting recreation, fish and wildlife, and aesthetic water quality criteria.

Shellfish taken commercially from the polluted saltwaters of Eastern Massachusetts are required to be treated to remove contamination before being distributed to the market, a practice in effect since 1933, largely due to shoreline combined sewer overflows. Some beaches are permanently closed * and others are often closed temporarily due to intermittently unacceptable bacterial levels as a result of combined sewer overflows.

5. The combined sewer problems of the Boston area have been studied many times over the years. A variety of solutions have been offered. These have included the "Deep Tunnel Plan" to store and convey all of the combined sewage out to sea and non-structural management programs involving solids flushing between storms.

* (At least five swimming areas of the Charles River, such as Magazine Beach, have been closed since 1959. Five others in Boston harbor have been closed temporarily because of high fecal coliforms.)

All studies have indicated that complete separation of the sewerage systems would be prohibitively expensive for the Boston Area, partly because of integral plumbing systems in homes and other buildings.

None of the proposals offered in the past to reduce combined sewer overflow problems has been implemented on an areawide basis.

6. Two cities are acting to separate historically combined sewers. The City of Cambridge is constructing new pipelines in the northeast area of the city paralleling combined sewers installed 50 to 90 years ago. The project is designed to reduce overflows to the Charles River Basin to a five-year storm frequency by sending most of the sanitary sewage and industrial waste to Deer Island.

The City of Boston has separated its sewers in all recent redevelopment projects. However, in all cases the separated pipelines are reported to have been joined back together into combined sewer systems at project boundaries.

7. Mathematical models were used in the EMMA Study to aid in predicting probable loadings caused by the major overflows in the core area. A design storm of 1-year severity and 8-hour duration was selected as the basis. While some of the techniques used in the modeling have been questioned, it is the best available data. Extending those data, we have estimated the approximate peak rate of combined sewer overflows expected to occur once a year in the drainage basins tributary to Boston Harbor as follows:

Parameter	Loading	Units
Peak flow rate	10,000	million gallons
BOD	100,000	pounds
Suspended solids	1,000,000	pounds
Coliform	50,000,000	MPN per 100 ml
Gross Solids	un-measurable	-

In addition to the above loadings to Boston Harbor, there appear to be about ten percent more loading occurring in the North Coastal Drainage Region. Smaller or larger storms than the selected design storm will result in smaller or larger discharges.

For comparative purposes, pollutants from separate urban stormwater systems in the Boston Harbor Drainage Watersheds, forecast to occur fifty times a year, are as follows:

Parameter	Loading	Units
BOD	135,500	pounds per event
Suspended Solids	555,500	pounds per event

8. The total rated capacity of the three existing Metropolitan District Commission combined sewage treatment facilities in operation or under construction, is 900 million gallons per day. That is about equal to the peak rated capacity of the Deer Island primary treatment plant and is also equivalent to about ten percent of the wet weather flow expected from a one-year design storm event.

9. It appears that the Cottage Farm facility (and probably the Charles River facility) will allow discharge of more than 85 percent of pollutants.* The Somerville facility is even less efficient. We consider this inadequate treatment for combined sewage. The performance data on the two operating facilities are insufficient to provide a basis for predicting

* (At rated design capacity.)

performance of future similar combined sewer overflow treatment stations at design flows.

From the information available, they appear incapable of providing either adequate pollutant removal or disinfection. *

10. As a holding tank, the Cottage Farm station is successful in avoiding emissions to the Charles River Basin during small overflow events. When the inflow has a volume of 1.2 million gallons or less, all flow is contained and goes to Deer Island for treatment.

The Somerville station was built to be another plant scale demonstration project but, due to inherent problems, has not been able to be operated to obtain reliable performance data.

The draft reports of performance of the demonstration projects have not been accepted by the EPA Office of Research and Development as of the end of 1976.

11. The EMMA Recommended Plan proposes four projects for combined sewer overflow regulation to reduce overflow regulation to reduce overflow problems in Dorchester Bay, the Charles River, Neponset River, and Boston Inner Harbor. These have been given priority numbers 3, 12, 13 and 15. These projects have not been based upon effectiveness in meeting discharge or water quality critera. No MDC projects are planned to correct combined sewer overflow problems existing in Norwood, Revere, Stoneham, Waltham, as well as Milford and other peripheral area communities in the North Coastal region. Responsibility for correction is often indeterminate.

12. The EPA, jointly with the Massachusetts Division of Water Pollution Control, has been instrumental, through the issuance of the NPDES Permit

---

* See note on page 5.100

and Enforcement Compliance Schedule Letter to the Metropolitan District Commission, in establishing the hydraulic capacity and process to be used for combined sewer overflow projects to be designed and constructed in the future, but has not established the level of treatment required. Projects are required to be of a size such that "untreated" discharges will not occur due to rainfalls of less than a storm of one-year severity and six-hour duration.

The four major proposed projects are to attain operational levels to meet effluent limits specified in the permit by the dates shown below:

Dorchester Bay, by February 1, 1983,

Charles River, including the Muddy River and Back Bay Fens, by February 1, 1983,

Neponset River, by February 1, 1983, and

Boston Inner Harbor, by January 1, 1986.

The scheduled completion dates for the first three projects are over two years sooner than the completion dates for secondary treatment of dry weather flows at Deer and Nut Islands.

The "best practicable control technology currently available" mentioned in the NPDES Permit issued to the Metropolitan District Commission had not yet been defined as of the end of 1976.

13. We observe that the NPDES requirements are deficient regarding combined sewage in three areas as follows:

> First, it is not stated how much, if any, of the combined wastewater should be retained and reconveyed to the Deer Island Treatment Plant;

> Second, the "effluent limits" do not contain specific requirements or even guidelines for removals to be obtained in the treatment process, limiting standards to be met in the effluent, nor standards to be achieved in the receiving waters. The degree of disinfection to be achieved or the upper limit of chlorine residual in the effluent also are not given; and
>
> Third, the permit mandates, in a general way, the process and three specific unit operations which must be used.

14. The rationale of allowing untreated overflows to continue in excess of those caused by one-year, six-hour storms has not yet been subjected to a cost-effectiveness analysis as required by regulations.

Analyses to be done in the Step 1 facilities planning and review process, together with the moving target of criteria and refinement in control technology are expected to result in the need for combined service regulation projects significantly different from the existing demonstration projects.

REFERENCES

5.1 Listing of communities in MAPC.

5.2 EPA
"Proceedings, Third Session, Conference In the Matter of Pollution of the Navigable Waters of Boston Harbor and Its Tributaries - Massachusetts."
October 1971.

5.3 Camp, Dresser & McKee/City of Boston
"Report on Improvements to the Boston Main Discharge System (CDM 257-12R)" Vol. 1 and 2,
September 28, 1967 - HUD [illegible]. P-Mass-3306.

5.4 Mass. Division of Water Pollution Control, Water Quality Section
"North Coastal Planning Area - 1975 Water Quality Management Basin Plan,"
July 1975.

5.5 Mass. Division of Water Pollution Control, Water Quality Section
"Charles River Basin - 1976 Water Quality Management Plan,"
July 1976.

5.6 Mass. Water Resources Commission DWPC
"A Pollution Survey of Boston Harbor"
August 1970, (1M-6-71-049858)

5.7 Joseph Cazzaza/Boston Dept. of Public Works
"Boston Still Faces a Pollution Control Problem - Deep Tunnel Plan Proposed As Solution" - September 1970.
Water and Wastes Engineering, Pg. 44-ff.

5.8 J. E. McKee/Camp, Dresser and McKee
"Loss of Sanitary Sewage Through Storm Water Overflows"
Journal of Boston S.C.E., Vol. 32, No. 2, 1947

5.9 EPA Region I, in cooperation with Boston Harbor Water Quality Management Coordinating Group.
"Interim Report on Combined Sewer Overflows in Boston Harbor"
October 13, 1971 - CW-106

5.10 Metcalf and Eddy, Inc.,"Wastewater Engineering and Management Plans for Boston Harbor - Eastern Mass. Metropolitan Area EMMA Study - Technical Data Vol. 7, Combined Sewer Overflow Regulation."
November 1975.

REFERENCES (Continued)

5.11 Metcalf and Eddy Inc./EPA
"Urban Storm Water Management and Technology: As Assessment"
EPA-670/2-74-040
December 1974.

5.12 Mass. DWPC,
"Boston Harbor Pollution Survey - 1972 Part A; Data Record of Water Quality and Wastewater Discharges."
April 1973.

5.13 Mass. Dept. of Public Health
"Report to the Interagency Task Force on the Survey of the Dorchester Bay Beaches."
1970.

5.14 EPA Region 1
"Joint Task Force Report on Major Manned M.D.C. Facilities Located in the Greater Boston Area."
Draft, May 1976.

5.15 Camp, Dresser & McKee/City of Boston
"1975 Supplement to 1967 Report on Improvements to the Boston Main Drainage System" (Facilities Plan)
November 1975.

5.16 U.S. EPA
"Proceedings, Second Session, Conferences in the Matter of Pollution of the Navigable Waters of Boston Harbor and Its Tributaries-Mass."
April 30, 1969

5.17 U.S. Public Health Service
"Pollutional Effects of Stormwater and Overflows from Combined Sewer Systems: A Preliminary Appraisal."
U.S. Dept. of Health, Education and Welfare.
1964.

5.18 David R. Horsefield/Camp, Dresser & McKee
"The Deep Tunnel Plan for the Boston Area."
Journal of the Boston Society of Civil Engineers, Reprint
October 1968.

5.19 Herbert G. Poertner, Bolingbrook, Illinois
"Practices in Detention of Urban Stormwater Runoff-
An Investigation of Concepts, Techniques, Applications, Costs.."
U.S. Department of the Interior, OWRR Project No. C-3380, 1974.

REFERENCES (Continued)

5.20 Camp, Dresser & McKee/City of Boston
"A Program for Pollution Abatement in the Old Harbor at Dorchester Bay."
July 1970.

5.21 Camp, Dresser & McKee/DWPC
"Water Quality Improvement of Tenean and Malibu Beaches"
November 30, 1972 - CDM 448-5-RT

5.22 Camp, Dresser & McKee/MAPC
"Alternative Regional Sewerage Systems for the Boston Metropolitan Area - Metro. Area Plan. Council."
(Summary and Draft Report Mar. 72)
October 1972 - HUD Project No. MASS P-135

5.23 C.E. Maguire, Inc./DWPC
"Report on the Water Quality Improvements of the Boston Back Bay Fens."
May 1973 (letter dated June 26, 1973) - MDWPC #72-06

5.24 J. Douglas Smith, Thomas J. Flaherty, Joseph J. Harrington
"Non-structural Controls for Combined Sewer Overflows"
Environmental Research & Technology Inc., Concord, Mass.
Undated (1976).

5.25 C. E. Maguire, Inc./MDC
"Engineering Report on The Charles River Estuary Pollution Control Facilities,"
November 1972. (Revised Basic Design Data, December 1973)

5.26 Camp, Dresser & McKee
"City of Somerville, Mass. Report: Improvements to the Sewerage System,"
April 30, 1974.

5.27 U.S. EPA
"NPDES Quarterly Non-Compliance Report for Period May 1, 1976 to July 31, 1976,"
Transmittal Letter dated October 8, 1976.

5.28 Metro. District Commission/Allyn St. C. Richardson, EPA Boston,
"Cottage Farm Combined Sewer Detention and Chlorination Station, Cambridge, Mass."
EPA Grant No. 11020 FAT,
Prepared for Office of Research and Development
(Undated, said to be a draft addition but not so marked.)

REFERENCES (Continued)

5.29 "Metro. District Commission Sewerage Division, Fifty-Sixth Annual Report - Fiscal Year Ending June 30, 1975," August 21, 1975.

5.30 C. E. Maguire, Inc./U.S. EPA
Untitled, Preliminary Draft Report on Somerville Pretreatment Facilities, Project No. 11023 DMR
July 16, 1976.
(Revised draft copy by K. Peter Devenis, January 1977).

Note: Ref. 5.28 reports performance for the first four years of the Cottage Farm Facility regarding achieving coliform removals as follows:

a. The abstract states: 99.9% removed.

b. Page 1 states: Coliform reduced by greater than 80%, and approached 99.9% in 1974.

c. Page 2 states: 99% coliform kill.

d. Page 57 states: Unfortunately, during 1971 and 1972, when a residual was found, a 99.9% kill was assumed and no tests were run.

e. Page 58 states: 3 samples showed removals of 43 to 100%. Assumed 99.5% removal.

f. Page 71 states: Average 99.2% kill.

(It is noted that the reported flow was usually about 10% of the rated design capacity.)

CONTENTS

Chapter 6

INFILTRATION/INFLOW

Section	Title	Page
A.	SEWER SYSTEM EVALUATION REQUIREMENTS	6.1
	1. Definitions	6.1
	2. Evaluation and Rehabilitation Requirements	6.3
	3. Guidance	6.7
B.	BOSTON AREA I/I PROBLEMS	6.7
	1. Infiltration	6.9
	2. Inflow	6.13
	3. Tide gates and weir overflows	6.17
C.	INFLUENCE OF EPA ON I/I IN THE BOSTON AREA	6.30
	1. NPDES REQUIREMENTS	6.31
	2. Responses to Requirements	6.33
D.	SUMMARY OF CHAPTER 6	6.35
	REFERENCES	6.39
	TABLE 6-1 Estimated Length of Sewers in MSD	6.11
	TABLE 6-2 Datum Planes and Tides	6.18

Chapter 6

INFILTRATION/INFLOW

Definitions and general requirements for sewer system evaluation of Infiltration/Inflow (I/I) are given in this chapter. Problems related to the condition of sewers which allow excessive infiltration/inflow in the study area are discussed. The status of I/I work in the Boston area is also given.

I/I problems are inherent in many sewers of the study area. The early development on filled ground, old deteriorated conduit materials, and the sewer elevations below the level of tides and groundwater, together with intentionally made connections from inflow sources, all contribute to unusually high amounts of I/I. The many sewer outlets located below high tide levels particularly contribute to the problem. These topics are included in this chapter.

A. SEWER SYSTEM EVALUATION REQUIREMENTS

Final Construction Grant Regulations, published February 11, 1974, Reference 6.1, define the terms and establish the requirements for evaluating and rehabilitating sewer systems for any treatment works under the Clean Water Grant Program. These are the only known regulations on the subject which have been issued by EPA. Pertinent sections are included below.

1. DEFINITIONS

The terms related to this subject are defined as follows:

a. Sanitary Sewer

"A sewer intended to carry only sanitary water or sanitary and industrial waste waters from residences, commercial buildings, industrial plants, and institutions."

b. Storm Sewer

"A sewer intended to carry only storm waters, surface run-off, street wash waters, and drainage."

c. Combined Sewer

"A sewer intended to serve as a sanitary sewer and a storm sewer, or as an industrial sewer and a storm sewer."

d. Infiltration

"The water entering a sewer system, including sewer service connections, from the ground, through such means as, but not limited to, defective pipes, pipe joints, connections, or manhole walls. Infiltration does not include, and is distinguished from, inflow."

e. Inflow

"The water discharged into a sewer system, including service connections from such sources as, but not limited to, roof leaders, cellar, yard, and area drains, foundation drains, cooling water discharges, drains from springs and swampy areas, manhole covers, cross connections from storm sewers and combined sewers, catch basins, storm waters, surface run-off, street wash waters, or drainage. Inflow does not include, and is distinguished from, infiltration."

f. Infiltration/Inflow

"The total quantity of water from both infiltration and inflow without distinguishing the source."

g. Excessive Infiltration/Inflow

> "The quantities of infiltration/inflow which can be economically eliminated from a sewer system by rehabilitation, as determined by a cost-effectiveness analysis that compares the costs for correcting the infiltration/inflow conditions with the total costs for transportation and treatment of the infiltration/inflow, subject to the provisions in.....(Section on requirements for sewer system evaluation and rehabilitation.)"

2. EVALUATION AND REHABILITATION REQUIREMENTS

The same Regulations require that all applicants for grant assistance awarded after July 1, 1973 must demonstrate to the satisfaction of the Regional Administrator that each sewer system discharging into the treatment works project for which grant assistance is made is not or will not be subject to "excessive" I/I. The determination whether excessive I/I exists may take into account, in addition to flow and related data, other factors such as cost-effectiveness, public health emergencies, the effects of plant bypassing or overloading, or relevant economic or environmental factors.

The determination whether or not excessive I/I exists will generally be accomplished through a sewer system evaluation consisting of (a) Certification by the State Agency; and when necessary (b) An I/I Analysis; and if appropriate, (c) a sewer system evaluation survey followed by rehabilitation of the system to eliminate the excess I/I, as follows:

a. Infiltration/Inflow Analysis

(1) "The infiltration/inflow analysis shall demonstrate the non-existence or possible existence of excessive infiltration/inflow in each sewer system tributary to the treatment works. The analysis should identify the presence, flow rate, and type of infiltration/inflow conditions, which exist in the sewer system. Information to be obtained and evaluated in the analysis should include, to the extent appropriate, the following:

(a) Estimated flow data at the treatment facility, all significant overflows and bypasses, and, if necessary, flows at key points within the sewer system.

(b) Relationship of existing population and industrial contribution to flows in the sewer system.

(c) Geographical and geological conditions which may affect the present and future flow rates or correction costs for the infiltration/inflow.

(d) A discussion of age, length, type, materials of construction and known physical condition of the sewer system.

(2) For determination of the possible existence of excessive infiltration/inflow, the analysis shall include an estimate of the cost of eliminating the infiltration/inflow conditions. These costs shall be compared with estimated total costs for transportation and treatment of the infiltration/inflow. Cost-Effectiveness Analysis Guidelines, which contain advisory information, should be consulted with respect to this determination.

(3) If the infiltration/inflow analysis demonstrates the existence or possible existence of excessive infiltration/inflow a detailed plan for a sewer system evaluation survey shall be included in the analysis. The plan shall outline the tasks to be performed in the survey and their estimated costs."

b. Sewer System Evaluation Survey

(1) "The sewer system evaluation survey shall consist of a systematic examination of the sewer systems to determine the specific location, estimated flow rate, method of rehabilitation and cost of rehabilitation versus cost of transportation and treatment for each defined source of infiltration/inflow.

(2) The results of the sewer system evaluation survey shall be summarized in a report. In addition, the report shall include:

(a) A justification for each sewer section cleaned and internally inspected.

(b) A proposed rehabilitation program for the sewer systems to eliminate all defined excessive infiltration/inflow."

c. Rehabilitation

(1) "The scope of each treatment works project defined within the Facilities Plan as being required for implementation of the Plan, and for which Federal assistance will be requested, shall define (1) any necessary new treatment works construction, and (2) any rehabilitation work determined by the sewer system evaluation to be necessary for the elimination of excessive infiltration/inflow. However, rehabilitation which should be a part of the applicant's normal operation and maintenance responsibilities shall not be included within the scope of a Step 3 treatment works project.

(2) Grant assistance for a Step 3 project segment consisting of rehabilitation work may be awarded concurrently with Step 2 work for the design of the new treatment works construction."

d. Sewer Use Ordinance

In addition, a sewer use ordinance is necessary as a part of this requirement as follows:

Sewer Use Ordinance

> "Each applicant for grant assistance for a Step 2, Step 3, or combination Steps 2 and 3 project shall demonstrate to the satisfaction of the Regional Administrator that a a sewer use ordinance or other legally binding requirement will be enacted and enforced in each jurisdiction served by the treatment works project before the completion of construction. The ordinance shall prohibit any new connections from inflow sources into the sanitary sewer portions of the sewer system and shall ensure that new sewers and connections to the sewer system are properly designed and constructed."

e. Procedures

The same regulation gives procedures to be followed on a project-by-project basis. Unless the applicant establishes to the satisfaction of the Regional Administrator that the treatment works project for which grant application is made will not be significantly affected by any subsequent rehabilitation program, no Step 2 or Step 3 grant may be awarded before the I/I analysis is complete.

Section 201 of Public Law 92-500 contains the following condition:

> "(g)(3) The Administrator shall not approve any grant after July 1, 1973, for treatment works under this section (section 201) unless the applicant shows to the satisfaction of the Administrator that each sewer collection system discharging into such treatment works is not subject to excess excessive infiltration."

3. GUIDANCE

A document entitled "Guidance for Sewer System Evaluation" was published in March 1974, reference 6.2. It emphasizes that extraneous water from I/I sources reduces the capability of sewer systems and treatment facilities to transport and treat wastewaters. It states that the analysis should be made for each sewer system tributary to the treatment works project and should not be limited by political jurisdiction or sewer types. The grant applicant is responsible for the entire sewer system evaluation and any rehabilitation to eliminate excessive I/I. The sewer system included in the evaluation should originate at the wastewater sources, such as a residence or commercial building, and terminate at the wastewater facility.

Both the guidance pamphlet and the Regulations were based, in part, upon an earlier American Public Works Association Manual of Practice entitled "Prevention and Correction of Excessive Infiltration and Inflow Into Sewer Systems" published January 1971, reference 6.3.

B. BOSTON AREA I/I PROBLEMS

In most communities, infiltration occurs when leaky sewers are situated at an elevation wherein groundwater is continuously or intermittently above the level of the sewer. Intermittent infiltration usually occurs with some time lag after the occurrence of precipitation which causes the groundwater level to rise. Modern sewers are normally constructed and tested to assure the infiltration rates, or the amount of leakage, will be quite small.

Inflow generally occurs when direct connections, often illegal ones, are made to a sewer from a source of runoff. Combined sewers, as in Boston, provide direct inflow connections. Rainwater leaders directly connected to sewers are another example. With inflow, there is virtually no time lag after the start of precipitation; the flow in the sewer increases almost immediately. One of the methods of distinguishing between inflow and infiltration is to analyze flow records for a small area of a system during wet weather and during dry weather. The time lags after precipitation until increased flow occurs usually reveal whether the source is inflow due to direct connections or infiltration due to leaky sewers. This determination is important because the approach and rehabilitation efforts are quite different.

The sewers of Boston were designed to carry combined sewage and stormwater. They were originally designed to carry stormwater and groundwater only with sewage excluded by law. Later sanitary sewage was permitted to be discharged into these stormwater sewers.

In Chapter 1, we reviewed the early-day construction of sewers, which were extended at flat slopes through filled ground and which, starting in the year 1833, were allowed to have sanitary sewage connected into them. Finally, because sufficient capacity was not available to convey the combined sewage out of the built-up area, numerous outlets to the nearest watercourses were provided to minimize backup, and because most of the outlets are situated below the high tidal level, the outlets were usually fitted with tide gates to prevent seawater inflow.

For purposes of this study, we choose to divide the subject into three headings: (1) Infiltration, (2) Inflow, and (3) Tide Gates and Weir Overflows.

1. INFILTRATION

To appreciate the magnitude of potential infiltration one must know the length, location and condition of the sewers tributary to the treatment plants.

The existing MSD has 225.57 miles of interceptors. About 5,300 miles of community sewers are connected at 1862 points according to the Fifty-Seventh Annual Report of the MSD. Those figures do not include building sewers, estimated to number some 400,000. We did not find that the length of building sewers in MSD has been estimated; they may be approximately equal in length to the public sewers. For our purposes, we assumed 10,000 miles of buried pipelines connected to the Deer Island and Nut Island plants.

The length of sewers serving each plant is not given. We have made an approximation based on the length of sewers in each member community. For the four communities served by both plants, we prorated the length in proportion to population. Our estimate of the approximate length of sewers in the two systems is given in Table 6-1.

Conditions which contribute to infiltration are leaky sewers and manholes and the presence of groundwater around the sewers. In Boston, both conditions exist. In addition, sewers located along waterways are subject to nearly continuous infiltration, particularly through the highly permeable sandy soils of the beach areas.

The fact that excessive quantities of infiltration are present has been documented in various reports over the years. The 1967 "Report on Improvements to the Boston Main Drainage System," reference 6.4, discusses at length what at that time was called extraneous flow. The Report documents a study of sewer measurements made during dry weather at 25 points throughout Boston having a tributary area of 6.5 percent of the City. The measurements showed that infiltration rates into separate sanitary sewers averaged 1500 gallons per acre per day (gpad) with a maximum of 17,300 gpad; infiltration into combined sewers averaged 17,500 gpad with a mixture of 58,000 gpad. Thus the maximum infiltration rate into combined sewers was was found to be over 3 times that for separate sanitary sewers, and the average amount is twelve times greater than for sanitary sewers. Unless the sewers are rehabilitated, a capacity allowance to treat this enormous quantity of infiltration water must be made when sizing treatment facilities.

The conveyance facilities recommended in that report (the Deep Tunnel Plan) used 2,500 and 17,500 gpad as average infiltration

TABLE 6-1

ESTIMATED LENGTH OF SEWERS IN MSD

(Miles)

Type	Deer Island	Nut Island	Total
MDC Tunnels	11	-	11
MDC Interceptors	159	66	225
Community Sewers	3,000	2,300	5,300
Building Sewers (Estimated)	2,830	1,634	4,464
Total (Approximate)	6,000	4,000	10,000

rates for existing areas served by sanitary sewers (13,500 acres) and combined sewers (7,000 acres) respectively. The same data were reviewed in the 1975 supplement, reference 6.5, and the same infiltration rates were recommended eight years later. Using the above data, we have computed that from the sewered area of Boston, the fraction of wastewater due to infiltration alone is more than 156 million gallons per day. It is observed that most of this extra flow would go to the Deer Island Treatment Plant during dry weather. The existing plant was at that time under construction and had been designed to treat an average daily flow of 329 mgd from the entire Northern Sewerage District. It is further noted that almost half the capacity of the Deer Island Plant would immediately be required for infiltration from Boston alone.

A 1974 report on the Somerville sewer system, reference 6.6, states that 37 percent of the flow from that community is due to infiltration.

The 1972 report on "Alternative Regional Sewerage Systems for the Boston Metropolitan Area, reference 6.7, includes an analysis of the Nut Island system. It was found that sewage flows vary seasonally. The spring flows were 27 mgd higher than in the fall. A comparison of sewage flow with rainfall and with stream flow at the USGS Wellesley gage was made and it was found that sewage flow varied directly with the flow in the Charles River but not with rainfall. It was concluded that groundwater was the probable source of infiltration in the Nut

Island system.

The recent EMMA study, reference 6.8, made a preliminary allowance for infiltration, pending results from future I/I analyses. Technical Data Volume 2 selected infiltration allowances ranging from 500 gpad for new sewers in upland areas to 6,000 gpad for old sewers in the low-lying areas. These figures were converted to a per capita basis yielding an allowance of 30 to 120 gallons per capita per day except in the old downtown area, where 5,000 gpad was selected for sewers tributary to the Deer Island Plant irrespective of population. The EMMA study predicted peak infiltration from the City of Boston as 65 mgd tributary to Deer Island and 20 mgd tributary to Nut Island. When predicted peak infiltration from the balance of the MSD is added to Boston's, the total is 200 mgd for the Deer Island service area and 120 mgd for the Nut Island service area. This is equivalent to 61 and 87 percent of the average recorded plant inflows during FY 1975-76 at the two treatment plants. The year 2000 average daily infiltration was predicted to be 129 mgd for Deer Island and 58 mgd for Nut Island.

The first report of the Metropolitan Sewerage Commissioners 1899, reference 6.9, showed daily leakage of groundwater amounting to 100 gallons per inhabitant per day.

2. INFLOW

Inflow, according to the EPA definition, includes the water discharged into a sewer from such sources as connections from storm sewers, catch basins, surface runoff, street wash waters, or drainage, as well as roof leaders, area drains, cooling water and the like. It is no accident that there is inflow in Greater Boston; the sewer systems were planned that way in the first place.

State laws passed in 1907 and in 1918 required works necessary to complete the separation of sewage from stormwater and provided a basis for financing the work.

The 1967 Report on "Improvements to the Boston Main Drainage System," reference 6.4, states that excessive storm water was found to occur from roof, foundation and areaway drains in addition to catch basins connected to sewers.

Both Federal and State regulations prohibit new inflow connections to the sewer system, yet these two agencies are major offenders. These agencies are exempt from local building ordinances and inspections and, as a general rule, construct their facilities with roof leaders and area drainage connected to sewers.

It is generally conceded that it is probably physically impossible to separate roof leaders and most other inflow sources in the plumbing of existing buildings in Boston. Based upon this, there has been a general assumption that it is not possible or economic to provide separate sewers in Boston. This is not true. Provision of separate sewers in Boston to handle street drainage would immediately reduce inflow by more than half. As buildings are replaced or remodeled additional separation can be accomplished.

Boston is overdue for such a separation program, which should be initiated now, regardless of cost. The main sewers in Boston are some of the oldest in the U.S.A., with many of them over 100 years old and most over 75 years. They have reached the limit of their useful life. Most of these sewers are of brick and these bricks are falling out, with large numbers of bricks arriving at headworks grit chambers after storms. A number of sewer collapses have occurred, one reported to be two blocks long. Some streets have been restricted to traffic due to deterioration of the sewer mains. Because sewer replacement is inevitable, the replacement should provide separation of storm waters and sanitary sewage.

No surveys of sewer condition were found, although it is probable that records do exist of areas where sewer failures have occurred. A detailed survey of condition of sewers should be performed and a program initiated for sewer replacement/separation. It is reported that some of the combined sewers have sediment accumulation of more than half their depth which further contributes to frequency of overflows, reference 6.16.

In addition, where sewer separation has been constructed in connection with Boston Redevelopment Authority projects, separation has terminated at project boundaries and separated sewers are connected to original combined sewers. These separate storm water sewers should be extended the few blocks to the harbor to relieve the combined sewers of this flow.

Reconstruction of existing sewers will have the additional benefits of reducing infiltration and also permit construction of the new sanitary sewers at slopes which will provide self-cleansing velocities.

In Volume 7 of the EMMA Report, reference 6.8, it was estimated that combined sewer overflows from the one-year design storm discharge at peak rate of 8,400 mgd. This amount is substantially due to wet weather inflow, and is equivalent to 18 times the sum of the average daily flows recorded during FY 1975-76 as being accepted at the two existing treatment plants.

If the authors of the EMMA report intend the 8,400 mgd peak overflow rate to also include inflow, which was separately reported as 309 mgd, then the difference or about 8,100 mgd is the peak infiltration rate or about 17 times the treated flow.

In a search of the available data, we find no information on the various sources of inflow into the sewers in the MSD.

We indicated in Chapter 5 that peak flow rates in the Deer Island system may be approximately ten times the pumping capacity of that system, principally due to storm water entering the combined sewers. The amount of storm water has not been measured and even if it were measured would not be meaningful by itself because of enormous quantities of seawater also entering the sewers.

3. TIDE GATES AND WEIR OVERFLOWS

We have reviewed the available data on inflow through tide gates in the Boston Area. Before discussing tide gates, however, it is desirable to explain the datum planes and tidal conditions in Boston Harbor.

a. Datum Planes and Tides

In order to utilize tidal data, one must have an understanding of the datum plane upon which the tidal data are based. Data are from Eldridge Tide and Pilot Book, 1976 edition, reference 6.10, and from reference 6.4.

Various agencies use different data planes as a basis of zero elevation. Four are relevant to facilities planning in the Boston area. (Values given below are approximate because of changing and conflicting data.)

(1) U.S. Geological Survey (USGS) maps are referenced offshore to mean lower low water, with shoreline shown at mean high water. At the same time, bench marks and land elevations are referenced to mean sea level datum. Mean sea level datum is equivalent to USC&GS sea level datum of 1929 and is adjusted periodically.

(2) U.S. Department of Commerce, National Oceanic and Atmospheric Administation (NOAA) uses mean low water as a basis to reference depth of soundings and tidal ranges. Mean low water is about 4.5 feet below mean sea level. Mean tidal range is 9.5 feet and spring tidal range is 11.0 feet.

(3) MDC Sewerage Division uses a datum plane 105.65 feet below USGS datum. Thus the spring tide range is elevation 101.1 to elevation 110.6 on MDC datum.

(4) Boston City Base is established at 5.65 feet below USGS datum which is equivalent to 100.00 feet higher than MDC.

The City of Boston has adopted for sewer design, the critical tide level of elevation 13.0 (MDC elevation 113.0). This was based on extensive analyses by Camp, Dresser & McKee on the frequency of occurrence of time that the height of tides equals or exceeds a given elevation. The highest tide of record is elevation 15.75, which exceeded the critical design level by thirty-three inches. The mean tide level is projected to increase by 14 inches in the next 50 years, reference 6.4. The extreme tidal range of record has been 18.45 feet.

A summary of equivalent tide levels in feet for the various agencies is presented in Table 6-2.

TABLE 6-2

DATUM PLANES AND TIDES

	Datum Plane			
	Boston	MDC	USC&GS	NOAA
Highest tide of record	15.7	115.7	10.1	14.5
Mean annual highest tide	13.6	113.6	7.9	12.4
Critical for design	13.0	113.0	7.3	11.8
Mean high water	10.6	110.6	5.0	9.5
Mean tide level	5.8	105.8	0.2	4.7
Mean sea level	5.6	105.6	0.0	4.5
Mean low water	1.1	101.1	-4.5	0.0
Boston Base	0.0	100.0	-5.6	-1.1
MDC Base	-100.0	0.0	-105.6	-101.5

The range of the tide differs from day to day according to the position of the sun and the moon. When the sun and the moon are pulling along the same axis as they do at full moon or new moon, the tide rises higher than usual and is called a "spring tide." When the sun pulls at right angles to the moon fourteen days later, we have a "neap tide," with minimum tidal range. Typical spring and neap tidal ranges are 12 feet and 6 feet, respectively, for Boston Harbor.

When either full moon or new moon phases occur at perigee, there will be spectacular high tides.

The actual height of tides may vary from predicted height due to winds. In Boston Harbor, winds often cause the water to be higher than predicted.

b. Tide Gate Problems

While some sewers in Boston Proper and surrounding low-lying communities are located below low tide and are subject to I/I continuously, many are located somewhere between low tide and high tide. These sewers were designed to discharge into tidal waters only during periods of low water. During periods of high water, a phenomenon occurring at regular intervals of 12 hours and 24 minutes, it was intended that the sewage be stored in the sewers. During the periods of high tides the saline waters were meant to be excluded from the sewers by tide gates. Tide gates are known to exist on MDC interceptors and on the sewers of several member communities. Although only five member communities have combined sewers, there are reports that tide gates exist in other communities as well. The 1976 Joint Task Force Report, reference 6.11, states:

> "Based on the population, flow from North Hingham should be 450,000 gal/day. An average of 600,000 gal/day is received on a normal day. On January 28, 1976, 2,700,000 gallons was received. High chloride concentrations and salt water fish have been found in the pumping influent on high flow days. It is thought that in addition to infiltration, tide gates are sometimes open."

A survey of outlet structures in the City of Boston was conducted as a part of the CDM 1967 study, reference 6.4. Appendix D of their Report lists the condition and capacity of outlets at 256 locations.

At 126 locations there were one or more structures noted as having tide gates. At the other 130 locations, there were weirs, which presumably overflow above normal high tide, or other devices, which presumably are open only at low tides. Some of the weirs (which have no tide gates to resist inflow) permit unrestricted seawater inflow during high tides and, due to general area subsidence, permit increasing inflow each year.

Many of the structures are huge and have more than one tide gate each. Some have tide gates in series and some tide gates are as big as an 8-foot square or a 5 x 9-foot rectangle.

While most tide gates are of metal, reports indicate some are of wood and in poor condition. It is also reported that some tide gates are manually operated sluice gates, but their location and procedure for operation (and closure) is not identified.

Typical comments in the referenced study for outlet structures with tide gates under the heading "observed condition" are as follows:

> "Tide gates stuck open. Heavy backflow on rising tide and raw sewage discharging in falling tide."
>
> "Sewer surcharged at high tide."
>
> "Tide gates missing."
>
> "Tide gate leaf has fallen off and is lying in invert."
>
> "Tide gate submerged at low tide."
>
> "Heavy timbers caught in tide gate
>
> "Dry weather flow discharging at low tide. Substantial flow discharging at high tide. Part of wooden tide gate missing."
>
> "Dry weather connection completely blocked and all flow discharging to outlet."
>
> "Tide gates leak at high tide."

As a part of that study the capacity of the outlets was calculated. For the 126 outlets with tide gates, the sum of the reported capacities is 9,600 mgd. This number indicates the quantity of sewage that can leave the sewer system through tide gate structures; no calculations are available to estimate the amount of water that can enter the system through missing or malfunctioning tide gates. No estimate is provided of inflows at non-gated weir overflow structures below highest tide levels.

The existence of faulty tide gates in the City of Somerville is documented in reference 6.6. That Report states that:

> "Concerns for the deleterious effect of combined sewer overflows resulted in the Commonwealth of Massachusetts placing the City of Somerville under state order in April 1972 to fix the tidegates on its overflow structures".......

The 1972 Report for the MAPC, reference 6.7, states that infiltration of river water and seawater into the MSD system from broken sewers and manholes and leaking overflow gates constitutes a problem of major proportions. They go on to say:

> "From whatever source, high infiltration flows in the system hasten the time when relief will be required. They also shorten the average detention time in the treatment units, reducing the efficiency of treatment. Should secondary treatment be required in the future, capacity would have to be provided for infiltration (I/I) flow, and there would also be additional costs for pumping and chlorination."

The 1972 "Engineering Report on the Charles River Estuary Pollution Control Facilities," reference 6.12, on the subject of source of overflows in Cambridge states that:

> "Presently the existing tide gates on the Binney Street and Cambridge marginal conduit sewer overflows are in poor condition causing them to be partially full of tide water and (Charles River) basin water, which in turn surcharges the City of Cambridge sewerage system," and
>
> "infiltration accounted for about 40% of total dry weather flow (in the North Charles Relief Sewer System). This high rate of infiltration is caused by two factors: the average age of sewer systems is 50 years or more old and the tide gate leakage."

The tunnels to Deer Island were built in the 1960's and the wastewater was intercepted to the Deer Island system. This action in effect, reversed the flow in the sewers and caused the water surface elevation in the sewers to be lower than it had been. As a result, the malfunctioning tide gates allow even larger quantities of water to enter the sewers.

We have found no investigation of tide gate operation since the Deer Island tunnels were put into operation. It may be possible that complete elimination or sealing of some of them would significantly reduce the inflow problem and at the same time not make the combined sewer overflow problems any worse. It should be determined if the tide gates are needed after provision of adequate pumping capacity at Deer Island.

The fact that the tidegates are faulty is not new.

The 1936 "Report of the Special Commission on the Investigation of the Discharge of Sewage into Boston Harbor and its Tributaries," reference 6.13, contains a finding of their 1929-1930 Survey that 11-1/2 percent of the flow in the Boston Main Drainage System is saltwater. They recommended correcting the leakage of saltwater occurring through the tide gates.

It is observed that the same document recommended that MDC provide devices for measuring sewage entering the MSD system.

The 1971 "Interim Report on Combined Sewer Overflows in Boston Harbor," reference 6.14 states that:

> "A major requirement for the efficient operation of combined sewer systems is that regulators and tide gates be operated properly and maintained in good working order. Experience has indicated that little has been done in the past by the responsible municipalities to adequately maintain regulators and tide gates. The majority of tide gates in Boston have been noted either as missing or in need of repair. As a result, significant amounts of sea water enter the system at high tides.... During 1969, 24 percent of the measured flow at Deer Island was attributable to salt water intrusion. The average chloride content was 3,700 ppm. The average chloride content of the Boston Harbor waters in the vicinity of the shoreline is approximately 15,400 ppm."

These findings do not include the effect of tide gate inflows from the Charles River with its low salinity.

The 1972 study of "Combined Sewer Overflows to the Charles River Basin," conducted for DWPC concludes, in reference 6.15,

> "Virtually all of the Cambridge
> Sewerage System that is presently
> considered separated actually
> functions as a combined system
> because of "common" manholes,
> missing or improperly positioned
> separation plates, broken or missing
> tide gates and other cross-connections."

Twenty-five years ago, the Massachusetts Legislature passed Chapter 645 of the Acts of 1951 which authorized expenditures for the Deer Island plant, tunnels and certain sewers, and

> "Rehabilitation of tide gates
> and pump stations."

Proceedings of both the Second Session and Third Session of the Conference in the Matter of Pollution of the Navigable Waters of Boston Harbor held in 1969 and 1971 report that tide gates are in need of repair. The question still arises today: Have the tide gates been corrected to eliminate inflow? We have attempted to answer that question by analyzing available data on chloride concentrations in the Deer Island and Nut Island systems.

(1) Deer Island System. About once a year the staff at Deer Island takes hourly samples at each of the four headworks and at the plant and analyzes them for chloride concentration. These data were made available to us for further evaluation.

(a) During March 9 and 10, 1970 the chloride concentration, or salinity, at Deer Island varied from approximately 1,000 to 5,000 mg/l. The concentration at Columbus Park headworks ranged from

1,500 to 12,000 mg/1. Very pronounced changes in salinity are observed. Salinity at Columbus Park increased rapidly one hour before each cycle of high tide, while the salinity at Deer Island increased about 2 hours later. The range of the predicted tide was 9.5 feet and the high tide was elevation 112.1 on MDC datum.

We have calculated the percentage of the wastewater that was saltwater inflow by the following method:

$$\%h = 100\ (Cc-Cs)\ /\ (Ch-Cs) \quad \text{(Equation 6.1)}$$

Where:

%h is percentage of Boston Harbor water in the wastewater,

Cc is salinity of combined wastewater,

Cs is salinity of sewage (assume 50 mg/1), and

Ch is salinity of Boston Harbor water (assume 15,400 mg/1).

The results indicate that during high tide the flow at Columbus Park was 78 percent Boston Harbor water. At Deer Island, the daily average flow computes to be 20 percent seawater. If pumping capacity at Deer Island were not restricted, the saltwater concentration in the sewage could well have been higher.

(b) During September 18 and 19, 1974, similar data were taken. The tides were slightly higher with a predicted range of 10.2 feet, and a high of elevation 112.6 on MDC datum. The pattern is the same as in 1970 except chloride concentrations are somewhat less. At high tide, the salinity was 8,300 mg/l at Columbus Park, and the range at Deer Island was 600 to 4,600 mg/l. These data indicate the saltwater inflow had been reduced to about 54 percent at Columbus Park and about 17 percent at Deer Island.

(c) During October 7 and 8, 1976 salinity data were again collected. The range of predicted tides was 9.7 feet, with a high of elevation 111.0 on MCD datum.

(i) The 24-hour flow at Columbus Park Headworks was 70 mgd and salinity varied from 1,300 to 8,900 mg/l. The data indicate 58 percent Boston Harbor water at high tide.

(ii) At the Winthrop headworks, the average concentration was 6,400 mg/l in a flow of 8 mgd. This represents 41 percent Boston Harbor water.

(iii) The 106 mgd flow at Chelsea Headworks had an average concentration of 1,400 mg/l indicating 9 percent Boston Harbor water. The lower salinity of the water in that part of the inner harbor, however, would indicate the inflow was actually higher.

(iv) At Ward Street headworks, the 47 mgd flow had chloride concentrations of 100 to 700 mg/l. Inflow at that system is largely from the Charles River Basin, with very low salinity, so the salinity in the sewage is not a valid indication of inflow.

Review of the data spanning five and one-half years indicates a reduction of approximately 30 percent of the inflow from saltwater sources during that period. The saltwater inflow into the Deer Island system still causes salinity variations of more than three-to-one at the plant and represents an average of at least 13 percent of the flow treated at Deer Island. This is equivalent to at least 44 mgd for 1976 and represents the capacity of one of the primary sedimentation tanks. Even though there appears to be less inflow through tide gates than in 1970, the senior power and pumping engineer still refers to tide tables to predict pumping demands, to aid in predicting when the influent gates must be choked at the headworks. If these gates were not choked, much more seawater would enter the treatment plant because this choking causes overflows through the tide gates rather than seawater inflow.

The last five Annual Reports of the MDC Sewerage Division each contains a list of all contracts made over the period July 1, 1971 to June 30, 1976. No contract work appears in those lists related to tide gate rehabilitation. Three contracts are shown for I/I studies on a siphon and two sewer relief lines.

We were advised by the MDC Construction Engineering Division that responsibility for rehabilitation of portions of the City of Boston sewerage system was transferred to the MDC about ten years ago. That transfer is said to include 200 or more tide gate structures and the Boston Marginal Conduit. The amount of rehabilitation performed and the responsibility for continued maintenance, however, remains unclear. The EMMA Report, reference 6.8, states that a program of inspection and rehabilitation of all tide gates began June 10, 1970. We have been advised that the program was delayed several years because of problems involving right of entry and because there physically was no access to some of the tide gate structures.

The EMMA Report, reference 6.8, has been adopted as the Basin Plan. It still recognizes inoperative or broken tide gates as a major problem. Chapter 2 states that portions of the interceptors require relief to meet the needs of MSD member communities and that improvements to local sewerage systems are needed also to reduce saltwater intrusion, rainwater inflows and groundwater infiltration. The Report continues:

> "For example, in the Northern sewerage system, measurements at the headworks show flows varying with the tides only changing during rainfalls when a continuous contribution from combined sewer area displaces this intrusion. About one-fourth of the flow at Deer Island is estimated to be saltwater intrusion.

We are not able to identify in any of the projects of the EMMA Recommended Plan a program to assure correction of the tide gate problem.

(2) Nut Island. There are no records of hourly tests for chloride concentration on the wastewater at Nut Island. Five days a week, however, chloride concentrations are determined on the 24-hour composite samples. During FY 1975-76, the reported values ranged from 140 to 700 mg/1.

In the absence of hourly data, we could not correlate concentration with hourly tide levels. We have, however, correlated daily variations of chloride concentration at Nut Island with perigee and apogee at which times the high water levels vary by several feet. We found that during the days when the high water level was at its highest the wastewater at Nut Island contained approximately three percent Boston Harbor water according to equation 6.1. The MSD staff advises that entry of saltwater fish and saline inflow occurs through open manholes submerged during high tide when the covers are removed by vandals.

C. INFLUENCE OF EPA ON I/I IN THE BOSTON AREA

Region I of EPA has been a party to numerous planning programs and enforcement conferences wherein I/I problems and especially the malfunctioning tide gates have been identified as a major problem.

The EPA planning section log of projects reviewed shows 24 projects in the study area; two, Watertown and Newton, are noted as having applied for grant assistance to perform I/I studies and one, Cambridge, has applied for a project involving sewer separation. The EPA did not require an I/I analysis or sewer system evaluation as a condition of the grant made to MDC for the Charles River combined sewer overflow detention and chlorination station project.

The scope of the EIS being prepared on some of the projects in the EMMA Recommended Plan does not include the subject of sewer system rehabilitation or size of proposed facilities.

The 1976 Needs Survey reports zero costs required in the sewer rehabilitation category in many study area communities known to have serious I/I problems.

The EPA has taken action to cause the investigation of I/I and tide gate problems through the NPDES process.

1. NPDES REQUIREMENTS

We have reviewed a sample of 23 NPDES permits in the study area. Permits issued to some agencies contain requirements regarding I/I as follows:

a. City of Boston was issued a permit April 2, 1975 which requires:

> "The City of Boston shall check all tide gates at least twice a year to see that they are working properly, and repair them, if necessary. A summary of tide gates shall be made to the Regional Administrator and Director by the 15th of each July and January for the previous six months indicating number of gates checked, number inoperative, number in good working order, number repaired, and numbers to be repaired. On the last item, reasons for non-repair shall be given."

b. City of Somerville was issued a permit December 24, 1974 which requires:

"Commence construction of the approved program of combined sewer manhole reconstruction by April 1, 1976 and tide gate rehabilitation by September 15, 1975."

c. Metropolitan District Commission was issued a permit August 16, 1976 which requires:

"The MDC shall check all tide gates owned and controlled by them at least twice a year to see that they are working properly and repair them if necessary. A summary of the conditions of the tide gates should be made to the Regional Administrator and Director by the 15th of each July and January for the previous six months indicating number of gates checked, number inoperative, number in good condition, number repaired, and numbers to be repaired. On the last item, reasons for non-repair should be given."

d. Metropolitan District Commission also was issued an Enforcement Compliance Schedule Letter (ECSL) dated August 11, 1976, which requires two I/I analyses, one for the sewer system tributary to Deer Island and one for the sewer system tributary to Nut Island. The six requirements and dates are the same for each:

"(1) By September 1, 1976 initiate the I/I analysis of the South System (see 40 C.F.R. 35.927-1).

(2) By January 1, 1977 submit an interim report summarizing the I/I analysis indicating preliminary results.

(3) By October 1, 1977 complete the I/I analysis of the South System and submit to the Regional Administrator for review and the Director for approval (see 40 C.F.R. 35.927-1).

(4) By January 1, 1978 initiate the sewer system evaluation survey of the metropolitan sewerage system tributary to the Nut Island Treatment Plant (see 40 C.F.R. 35.927-2), if deemed necessary by the Regional Administrator and/or Director.

(5) By April 1, 1979 complete the survey and submit the results and proposed implementation plan with schedule to the Regional Administrator and Director. The permit may be modifed to include the plan and its schedule.

(6) Progress reports on the project should be submitted to the Regional Administrator and the Director on the first of each April and October for the period covered by this schedule."

2. RESPONSES TO REQUIREMENTS

a. City of Boston is on record as responding to the requirement to check their tide gates. On July 12, 1976, they advised that of the 125 outlets listed in the Permit:

72 are checked weekly,
3 are checked twice weekly,
47 outlets have no tide gates to be checked,
1 is owned by BRA,
1 is owned by Mass. Turnpike Authority, and
1 is never operated.

b. The City of Somerville has advised that their tide gates have not been repaired and they will seek clean water grant assistance to repair them.

c. MDC responded on the subject of tide gate rehabilitation as follows:

(i) On the Boston Main Drainage System:

77 new tide gates installed,
1 repaired
2 cleaned, and
2 new tide gates to be installed under contract being prepared for advertising.

(ii) Charleston. Construction completed with nine new tide gates.

(iii) East Boston. Contract being prepared for advertising for eleven new tide gates.

(iv) Chelsea. 5 new tide gates installed.

We were advised the above work had been done over a period of about four years. MDC report dated June 10, 1976 showed no change from February 10, 1976.

The EMMA Recommended Plan contains a schedule listing two projects, priority No. 2 and No. 4 as the I/I analyses on the south system and north system, respectively, at a cost of $1,992,000. The bar graph shows the analyses to be completed in the fall of 1977 which corresponds to the requirements of the ECSL. The bar graph also shows sewer evaluation field surveys being conducted during the period January 1978 to spring of 1979. This also complies with the ECSL schedule. We have been advised by the Compliance Branch of EPA that the MDC is behind schedule and has not submitted the reports on the progress of the I/I analyses as required by the NPDES/ECSL conditions.*

---

* (EPA advises that I/I Analyses for the North and South MDC systems were completed in 1978.)

D. SUMMARY OF CHAPTER 6

1. EPA is encouraging design of individual projects before the determination is made that some projects are cost-effective based on future sewer system analyses. (EPA advises in 1978 that no projects would be designed before I/I analyses are done).

2. EPA regulations require grant applicants to make an infiltration/inflow (I/I) analysis to demonstrate the non-existence or possible existence of excessive I/I in each sewer system tributary to grant assisted treatment works; the applicant must then proceed with a sewer system evaluation (field) survey, where indicated, to determine the cost of rehabilitation versus the cost of transportation and treatment of each source of I/I. This has not yet been done in the Metropolitan Sewerage District.

3. Very high rates of infiltration into Boston area sewers have been documented since the last century. The EMMA Study predicts a unit infiltration allowance of 30 to 120 gallons per capita per day and more in some of the old downtown areas. The EMMA Recommended Plan will provide relief sewers and extra treatment capacity due to peak infiltration rates of 200 mgd at Deer Island and 120 mgd at Nut Island.

Planned capacity allowances of average daily flow from extraneous sources, in mgd, are:

	Deer Island System	Nut Island System	Total
Infiltration	129	58	187
Inflow	41	10	51
	170	68	238

This amounts to an average of 116 gallons per capita per day in the Deer Island system and 87 gallons per capita per day in the total District.

4. Facilities Planning is scheduled to be completed and design is scheduled to be started on the treatment plant expansion projects based on the flows in the EMMA Report, before the I/I evaluations have determined whether it is cost-effective to treat extraneous flow or to rehabilitate the system, according to the NPDES permit schedule.

5. Plumbing and sewers in Boston, Brookline, Cambridge, Chelsea and Somerville were designed to receive surface water inflows.

The EMMA Report predicts wet weather inflow without I/I reductions at 6-day intervals and suggests planning facilities to handle 8,400 mgd peak flows. After being mixed with sewage, most of this inflow would be allowed to overflow at the shoreline or to rivers.

6. More than one hundred tide gates, intended to keep seawater out of sewers, exist on combined sewer outlets located in the tidal zone. Continued tide gate malfunction and backflow over overflow weirs allow enormous quantities of direct inflow from these sources. Average saltwater inflow requires pumping to be controlled at high tides, and necessitates choking of headgates with resultant overflows of untreated wastewater. An unknown amount of inflow also occurs at ungated overflow weirs located below maximum tide level.

7. A program for replacement of existing deteriorated combined sewer trunk lines is an immediate necessity. Such replacement would permit separation of sanitary sewers and storm sewers which would reduce stormwater inflow more than 50 percent and permit elimination of the need

for all or most combined sewer overflow tide gates and overflow weirs which are a major source of inflow.

8. There are insufficient data available at the present time to accurately estimate costs for sewer rehabilitation to reduce I/I and to correct the tide gate problems. The EMMA Recommended Plan does not contain a program for such rehabilitation work nor is such work included in the cost estimates.

REFERENCES

6.1 EPA
"Final Construction Grant Regulations"
Part 35, Sections 35.905-5 through 35.927-5.
February 11, 1974.

6.2 EPA
"Guidance for Sewer System Evaluation."
March 1974.

6.3 APWA/EPA
"Prevention and Correction of Excessive
Infiltration and Inflow, A Manual of Practice."
Water Pollution Control Research Series 11022 EFF 01/71.
Program 11022 EFF, Contract 14-12-550.
January 1971.

6.4 CDM/City of Boston
"Report on Improvements to the Boston Main
Drainage System."
September 1967.

6.5 CDM/City of Boston
"1975 Supplement to 1967 Report on Improvements
to the Boston Main Drainage System, (Facilities Plan)."
November 1975.

6.6 CDM/City of Somerville
"Report, Improvements to the Sewer System."
April 30, 1974.

6.7 CDM/MAPC
"Alternative Regional Sewerage Systems for
the Boston Metropolitan Area."
March 1972.

6.8 Metcalf & Eddy/MDC
"Wastewater Engineering and Management Plan
for Boston Harbor - Eastern Massachusetts
Metropolitan Area - EMMA Study."
March 1976.

6.9 Metropolitan Sewerage Commissioners
"Main Drainage Works of Boston and Its Metropolitan
Sewerage District."
1899.

6.10 Eldridge Tide and Pilot Book
1976.

6.11 EPA
"Joint Task Report on Major Manned MDC Facilities Located in The Greater Boston Area."
DRAFT, May 1976.

6.12 CE MAGUIRE, INC./MDC
"Engineering Report on the Charles River Estuary Pollution Control Facilities."
November 1972.

6.13 Commonwealth of Massachusetts
"Report of the Special Commission on the Investigation of the Discharge of Sewage into Boston Harbor and Its Tributaries."
House Document No. 1600.
December 1936.

6.14 EPA, Region I
"Interim Report on Combined Sewer Overflows in Boston Harbor."
Prepared in cooperation with New England River Basins Commission, Boston Harbor Coordinating Group.
October 1971.

6.15 Process Research, Inc./DWPC
"Combined Sewer Overflows to the Charles River Basin, A Preliminary Study."
August 7, 1972.

6.16 Process Research, Inc./MDC
"Report on Study of Pollution Control Alternatives for Dorchester Bay."
1974.

CONTENTS

CHAPTER 7

EXTENT OF CONSOLIDATION

Section	Title	Page
A.	PRESENT REGIONAL SYSTEMS	7.1
	1. The Region Defined	7.2
	2. Wastewater Service Agencies	7.8
B.	WASTEWATER PLANNING	7.8
	1. Basin Planning	7.8
	2. Areawide Waste Treatment Planning	7.8
	3. EMMA Study	7.10
	4. Local Agencies	7.12
	5. EPA Influence	7.13
	6. Massachusetts Water Supply Policy Study	7.17
C.	COST OF SEWERAGE	7.19
	1. Size of System	7.19
	2. Study Area	7.22
	3. Individual Systems	7.26
D.	SUMMARY OF CHAPTER 7	7.28
	REFERENCES	7.30

CHAPTER 7

EXTENT OF CONSOLIDATION

"There are almost as many definitions of the Boston Metropolitan Region as there are studies concerned with its regional planning," according to the 1976 Phase 1 Report of Urban Systems Research & Engineering, reference 7.1. Five types of regions are cited as particularly important in the facilities planning process:

- those defined by natural condtions, such as river basins,
- those defined by actual political boundaries,
- those formed for federal data collection and analysis,
- those formed for areawide planning, including wastewater planning, and
- those used for operating waste management.

This chapter examines the extent of consolidated wastewater management being practiced in Eastern Massachusetts at present and being considered in the future. Emphasis is given to areas proposed for annexation to the Metropolitan Sewerage District. Comparative costs for sewerage of unsewered communities are also given.

A. PRESENT REGIONAL SYSTEMS

This section defines the region as considered in this study and summarizes the existing consolidated wastewater systems therein.

1. THE REGION DEFINED

The Study Area for this Report has been defined in the Introduction and Described in Chapter 1 of this Report.

"Boston," however, has been defined by various planning agencies as Boston Proper; The City of Boston, The Core Area, Greater Boston, and Metropolitan Boston. Its' Inner Suburbs and its' Outer Suburbs may or may not be included in Greater Boston or Metropolitan Boston. The Inner and Outer beltways, the major transportation corridors (Highways 128 and 495), are also used to define planning limits. Many kinds of available data, such as those normally published by EPA's Nationawide "Needs Survey" normally provide outputs only for the entire State.

A review of present natural and agency boundaries follows.

a. Natural Boundaries

Four basins naturally drain to Boston Harbor. As presented in Chapter 1, they are the watersheds of the Mystic, Charles, Neponset, and Weymouth Rivers. The North Coastal, the South Coastal, the Ipswich and the SuAsCo do not drain to Boston Harbor. The Merrimack, Nashua, Blackstone, and Taunton River Basins are on the fringes of the Study Area.

Classification and segmentation of Massachusetts river basins and basin planning being carried out by the Commonwealth of Massachusetts DWPC conforms to these natural watershed boundaries inpdependent of political jurisdictions.

b. Political Boundaries

The MSD, an agency of MDC, has 43 present member communities and serves all or a portion of 42 of them.

The Metropolitan Water District, also under the MDC, has 34 member communities but serves 44 communities.

The Massachusetts Bay Transportation Agency serves 79 cities and towns in the Greater Boston Area.

The Counties of Massachusetts appear to have played no part in planning or in providing services.

Boston Metropolitan area, as designated Standard Metropolitan Statistical Area (SMSA) 632 by the U.S. Census, includes the inner suburbs of Boston.

Because the SMSA does not coincide with any of the wastewater planning regions, projections for the census area must be disaggreated for wastewater planning.

The SMSA was used, however, for determining cost estimates for construction of facilities for correction of combined sewer overflows and stormwater discharges in the 1976 Needs Survey (referenced in Chapter 3), while other categories of needs were for the entire state.

A political situation exists in the Commonwealth of Massachusetts which may become important in the future administration of the Clean Water Grant Program: all cities and towns have contiguous boundaries. That is, there is no county areas outside the cities and towns. In some of the satellite and peripheral areas, only a very small percentage of a given community is developed. As a condition of a Clean Water Grant, the grantee must have existed as of October 18, 1972. Sewerage service for new communities developed after that date are considered the responsibility of the developer and are not grant eligible. Thus, in most states when a new community is developed, the costs for sewerage service is usually passed along to the residents in the price of the lot, often in the form of assessment bonds.

In Massachusetts, however, a town could have been 10 percent developed and 90 percent rural in 1972. As a result, sewerage facilities to serve future development in the former rural area would be eligible for grant if the service area was at least two-thirds developed as of October 18, 1972.

2. WASTEWATER SERVICE AGENCIES

Present wastewater agencies and their relationship to the region are listed below:

a. Metropolitan Sewerage District

The MSD currently encompasses an area of 517 square miles. Sewage is being contributed from only 209 square miles, reference 7.2, while 308 square miles or 60 percent of the MSD is without municipal sewage service. The estimated population contributing sewage to the

MSD is 1,980,083. The total population of the District by 1975 Census is shown as 2,108,074 persons, indicating that 200,000 persons or less than ten percent of the population is without sewer service. Many of the member communities have sewers only in a very small percentage of the area within their boundaries.

Several communities in the natural watersheds tributary to Boston Harbor are not members of the MSD. These are

Milford, Holliston, Millis Norfolk and part of Wrenton, which are in the Charles River Watershed,

Medfield, which has an AWT plant,

Medway, Franklin and Bellingham, also in the Charles River Watershed,

The North half of Foxborough at the headwaters of the Neponset River, which is outside the Study Area,

Avon, which is in the Weymouth River Watershed, and

Hull, which is on the dividing line of Boston Harbor and the South Coastal Watershed,

The MSD does not serve Holbrook in the Weymouth River Watershed. Holbrook is an MSD member however.

The MSD also does not serve Weston, Lincoln, Dover and Sherborn in the Charles River Watershed or Sharon in the Neponset River Watershed. The EMMA Report proposes that service be extended to serve these five towns.

The MSD now receives sewage from all or a portion of several communities that are outside the Boston Harbor Watersheds. These are:

> Revere, Malden, Melrose, and Wakefield which are tributary to the North Coastal Watershed,
>
> Reading, Wilmington, and Burlington, which are tributary to the Ipswich River north of Boston Harbor,
>
> Lexington, which is tributary to the Shawsheen and Merrimack Rivers,
>
> Bedford, which is tributary to the Shawsheen and Concord Rivers, and
>
> Natick, Framingham and Ashland, which are tributary to the Sudbury River in the SuAsCo Watershed which drains to the Merrimack River.

b. Charles River Pollution Control District

This District has new facilities under construction and plans to serve Franklin, Medway, and the north part of Bellingham at the headwaters of the Charles River. An AWT plant will provide treatment. The proposed discharge for this plant will be the most upstream discharge in the Charles River watershed. No NPDES permit has been issued.

c. South Essex Sewerage District

This District, in the North Coastal Watershed, is comprised of the communities of Beverly, Danvers, Peabody, Marblehead and Salem. This District is not meeting treatment requirements.

d. Lynn Regional System

This system which is comprised of the communities of Lynn, Saugus, and Nahant, is also in the North Coastal Watershed. The area is not meeting treatment requirements.

The state has permitted contractural obligations between communities for water pollution abatement purposes since 1967. It is a less cumbersome method of single purpose regionalization compared to formation of a special district.

e. Regional Septage Service

We were advised that the communities of Sudbury and Wayland in the SuAsCo watershed plan joint service for consolidated management of individual septic systems and for treatment and disposal of septage. An interview with the Town Engineer of Sudbury informed us that the town has applied to EPA for Step 3 funding of a treatment plant to handle septage from the two towns. The plant has not been designed, although an engineer has been selected.

We were told that all septic tanks are to be privately maintained with the individual responsible for employing private pumpers and haulers to convey the septage to the proposed treatment plant. Administration of the system is to be under jurisdiction of the Wayland Road Commissioners, although the method of financing and cost-recovery to be employed had not been decided upon at the time of the interview. Sudbury is presently on the basic priority list for a Step 3 grant of $525,000 for septage treatment.

B. WASTEWATER PLANNING

Wastewater planning is being performed concurrently by several agencies in overlapping areas.

1. BASIN PLANNING

Basin Planning, as noted earlier, is being done pursuant to Section 303 (e) by DWPC for natural watershed boundaries. DWPC has completed basin plans for only two of the nine basins in the Study Area.

2. AREAWIDE WASTE TREATMENT MANAGEMENT PLANNING

Section 208 planning is being done by the MAPC for a designated area comprised of 92 communities, reference 7.3.* The MAPC has 101 member communities however. Planning for the 92 communities is being done on a subregional basis. Subregional areas are defined on the basis of natural boundaries.

The Metropolitan Area Planning Council developed policy, according to reference 7.4, that

> "sewage facilities shall be constructed so that waters will be retained, wherever possible, in the drainage basin of original use. Stream flows will otherwise be reduced by volume of water exported, thus restricting downstream usage."

The Metropolitan Area Planning Council formulated an objective for its comprehensive planning program to:

> "Encourage the regional use, operation, and maintenance of facilities whenever possible."

We have been advised that annexation to a regional wastewater service agency is not viewed favorably by all communities. Marblehead was given as an example of a community which desired to own and control its own facilities. We were advised that Marblehead was forced to join the South Essex Sewer District but the mechanism requiring that action is not clear. Minutes of the MAPC Citizens Advisory Committee state that growth-policy statements prepared by the MAPC communities indicate an overwhelming number wish to control further growth; it is said that decisions to build sewers give implicit approval to more growth and sprawl.

---

* NOTE: The draft 208 plan is reported to have been released August 11, 1978.

"Home rule" granted under Article LXXXIX of the Massachusetts Constitution is said to be interpreted by communities and citizens as authority for municipalities to be responsive to environmental concerns including whether or not they should have growth-permitting utility services.

MAPC staff advises that no consolidation of facilities is favored because of likelihood of loss of potential reuse and reclamation opportunities in the satellite and peripheral areas.

MAPC is making projections of future wastewater flows. Their preliminary wasteloads, according to reference 7.3, are based on a range of 70 to 120 gallons of residential sewage per day and 0.8 to 1.7 gallons of residential septage per day. The MAPC Interim Output also lists facilities planning requirements for its member communities. "No apparent need" for wastewater facilities are shown for Dover, Hopkinton, Lincoln, and Sherborn, which are among the eight communities proposed inthe EMMA Report to be annexed to the MSD. We observe that these same communities are not in the state priority list.

3. EMMA STUDY

Wastewater planning has been studied in the EMMA Report (referenced in Chapter 3), for an area comprised of 109 communities, covering an area of 1600 square miles. The total area of the present Metropolitan Sewerage District is 517 square miles; sewer service is available to 208 square miles according to the MSD Annual Report for FY 75-76.

Fifty-six, or over one-half of the EMMA Study Area communities are located in watersheds not naturally draining to Boston Harbor. They do not contribute to the pollution of Boston Harbor.

Nine communities in the EMMA Study Area are not represented in the MAPC 208 project.

Bolton
Boxborough,
Carlisle,
Essex,
Gloucester,
Ipswich, and
Rockport

None of the above communities are recommended to be annexed to the MSD, however.

One community, Foxborough, is in the 208 project area but not in the EMMA Study Area.

Facilities planning for 52 separate projects is proposed in the EMMA Recommended Plan to provide wholesale sewer service to present member communities and an additional eight communities. The eight communities have an area of 85 square miles.

The following three communities would be added to the Deer Island Service area:

Lynnfield,
Lincoln, and
Weston.

The following five communities are proposed to be added to the MSD southern service area and would be served by Satellite AWT Plants under the EMMA Recommended Plan (or by the Nut Island Plant under an EMMA Option).

Dover,
Hopkinton,
Sharon,
Sherborn, and
Southborough.

Of the above 8 communities, three are not in the natural watersheds tributary to Boston Harbor. Service by MDC of these communities as proposed would constitute an interbasin transfer of water:

Lynnfield,
Southborough, and
Hopkinton.

The addition of the eight communities would increase the MSD service area from 208 to 293 square miles.*

It is noted that the 1976 Needs Survey does not show sewers are needed for four of the towns proposed to be added to the MSD.

No point sources of wastewater will be eliminated by addition of any of the eight communities because none have sewers at present. No documented wastewater problems in the eight communities was disclosed by our literature search. The rational for their selection of areas for expanding the MSD service area is unclear as is the reason that a 1600 square mile area was selected for EMMA Study.

* (The sewered population of the 8 communities is zero.)

At the same time, there are communities in the Boston Harbor Watersheds that have documented wastewater problems, such as Milford, that would appear to benefit by having service available to them.

The EMMA Report provides minimal attention to the peripheral area communities outside the expanded MSD service area on the basis that:

> "Serving the remaining communities by expanded Deer Island and Nut Island sewerage systems was not considered desirable because of long transport relief requirements; because such a system negates reuse possibilities; because out-of-basin transfers would occur; because additional flows would be diverted to Boston Harbor aggravating problems of treatment space, combined and old sewer remedial needs and feasibility capacities; and because construction costs would be higher."

Documentation of studies leading up to these findings is unavailable. *

4. LOCAL AGENCIES

Each city or town or wastewater agency may engage in facilities planning pursuant to Section 201 of Public Law 92-500. Few local agencies have a planning staff engaged full time in wastewater planning. The MDC, with an Environmental Planning Office is a notable exception. The MDC Director of Environmental Planning served as Project Manager of the EMMA Study. Actual Step 1 facilities planning is expected to be performed by consultants under contract with the MDC. Cities and towns almost always engage a consultant for facilities planning also.

---

* (A Management Plan does not automatically necessitate consolidation into one operating system.)

We understand that a decision was made in U.S. EPA headquarters in Washington several years ago to proceed with implementation of the Section 201 Construction Grants Program for individual projects in the EMMA plan area before completion of basin plans, or areawide plans required by other sections of Public Law 92-500.

5. EPA INFLUENCE

We have reviewed the Rules and Regulations promulgated by EPA and find an absence of written guidance on the subjects of need for sewers in an unsewered community and the desirability of consolidating wastewater treatment, disposal or management functions into regional systems.

These subjects have been under consideration and a statement of EPA policy is expected in the form of Program Requirements Memoranda (PRM).

A draft PRM entitled "Eligibility of Septic Tanks and Other Small Treatment Systems" was circulated to Regional Administrators in November 1976, reference 7.5.* That PRM if adopted, would establish policy that

> "Facility Plans should contain a complete and careful cost-effectiveness analysis of alternatives involving maintenance and/or new construction of treatment facilities for single family homes and clusters of homes...."

An analysis of low cost septic tank systems would be required in undeveloped areas or in sparsely developed areas currently on septic tanks.

---

* (Additional guidance has subsequently been provided.)

The draft PRM would establish that septic tanks are grant eligible with conditions, including the requirement for public ownership.

Vehicles and equipment for servicing small systems would also be grant eligible.

The draft PRM was proposed because of recognition of the fact that continued use of septic tanks has sometimes not been considered carefully when likely to be more cost-effective than collector, interceptor and treatment networks and costs of sewering small communities is beyond the capabilities of many users to pay.

Comments from Regions on the draft PRM included such remarks as

> "We should accept the fact that providing treatment in rural areas results in higher per capita discharges. "
>
> "Encouragement of septic tank use is more into the past."
>
> "Disagree that there are large numbers of exceedingly expensive projects planned."
>
> "Do not issue this proposed PRM."

Region I of EPA is credited with the first two comments noted above.

EPA Headquarters responded to the comments of the Regions as follows:

> "Sewering should not be required where on-site small systems would function adequately with proper maintenance. Each community should resolve its wastewater problems in a truly cost-effective way and there should be no financial dis-incentives for selecting the most cost-effective methods."

> "The need for the PRM has been demonstrated clearly by facility planning results to date. Seldom is the no-action or minimal action alternative considered. Rarely are the upgrading of existing systems and organization of suitable maintenance procedures looked at."

The State of Illinois Environmental Protection Agency, Division of Water Pollution Control, has issued "Guidelines for evaluating the "No Action" alternative in small, unsewered communities," dated September 15, 1976, reference 7.6. That Guideline requires the grant applicant to provide evidence in the form of stream sampling and discharge data to support allegations that septic systems are malfunctioning and need to be replaced with centralized sewerage systems. Cost guidelines are also given for comparisons with central systems.

EPA has also sponsored Technology Transfer Municipal Design Seminars on Small Wastewater Treatment Systems. Cost-effectiveness analyses are presented for five case histories in reference 7.7 where on-site disposal systems were compared with community systems. The community systems evaluated were

Conventional gravity sewers,
Small-diameter sewers,
Pressure sewers, and
Vacuum sewers.

EPA recently announced a research grant in the New England Region to the Maine Municipal Association to study methods of septage management in Falmouth, Maine. The project's goal is to discover an economical way to reintroduce septage into the environment. Septage, when compared to normal raw sewage, is said to have

20 times more BOD,
30 times more solids,
Increased bacteria counts, and
Far greater putrescent properties.

Reference 7.7 alleges that treatment centers often charge high disposal fees which are designed to discourage incoming septage with the result that a large part of untreated septage is land spread and eventually finds its way into waterways.

At the local level, EPA Region I has been influential through the NPDES permit process in encouraging the consolidation of sewerage service in areas remote from the present MSD system. The only interceptor sewer listed in the NPDES Compliance Schedule Letter issued to MDC is the Framingham Extension Sewer. Designated as EMMA priority item No. 14, it is a $22.4 million dollar project to convey raw sewage from the Natick-Framingham boundary to the site of the proposed Middle Charles AWT plant. It can immediately serve approximately 2,000 persons in Ashland and 50,000 persons in Framingham that are presently connected to local sewers. The project will have capacity to also serve the unsewered communities of Southborough and Hopkinton which are outside the Boston Harbor watershed and not members of MDC. Because no water quality problems are identified with those areas, the reasons for assigning this project a high priority are unclear. The NPDES Compliance Schedule Letter requires Step 1 facilities planning for the Framingham Extension Sewer to begin by April 1, 1977, which could effectively commit the MSD Nut Island Service Area to expand into more of the Sudbury River Watershed.

6. MASSACHUSETTS WATER SUPPLY POLICY STUDY

The report of the Massachusetts Water Supply Policy Study conducted in 1976 was recently published, reference 7.8. Although the Study emphasizes total water resources management, it also has a bearing on wastewater management.

Included is a finding that there is a lack of policy, standards and basic data on water resources in Massachusetts and that:

> There is general ignorance of the sources of water, the limitations, and compromises necessary,
>
> Intensive urban development occurs in areas that have the least natural water resource,
>
> There are many competitive uses of water and conflicting demands on water resources,
>
> There is uncoordinated resource planning, and
>
> The public's role in water resource management is not clearly defined and is not well understood.

The report also found the following to apply in the Commonwealth:

> Water users across the State are wasteful,
>
> Water demand will increase half as much per year as it did in the 1960's,
>
> There are gaps and overlaps of responsibilities of agencies, resulting in uncoordinated management,

> Local control is desirable and preferable,
>
> Historically, water management grew out of health concerns,
>
> There are no conservation programs, and
>
> Water conservation is needed in the Boston Metropolitan Water District.

Particularly aimed at the Greater Boston area, the Report cites specific recommended policies such as:

> Rehabilitation of existing utilities and separation of combined sewers where they exist, and
>
> New utilities should be built to solve existing problems, not as an incentive to growth.

Average domestic water use in Eastern Massachusetts is cited as 54 gpcd in the MDC Metropolitan Water District service area and 74.6 gpcd outside the MSD service area.

The Report further points out a strong two-way relationship between water supply and water quality. It is noted that the general intent for Public Law 92-500 is to accelerate programs upgrading the quality of surface water bodies and is not intended to eliminate discharges to land or groundwater.

C. COST OF SEWERAGE

This section examines the costs of different methods of providing service to presently unsewered communities or to future development in the satellite or peripheral areas.

1. SIZE OF SYSTEM

Cost of wastewater facilities is generally dependent on size and quanity. When unit costs decrease with an increase in total capacity, we have what is known as "economy of scale".

Monetary Economy of scale can be expressed as follows:

$$CL + Cs\ (QL/Qs)^{X} \qquad \text{(Equation 7.1)}$$

Where:

C_L Is the cost of large facility,
C_s Is the cost of a small facility,
Q_L Is the capacity of a large facility,
Q_s Is the capacity of a small facility,
and X is the scale factor.

When X is unity, costs are directly proportional to flow and there is no economy of scale. When X is greater than unity, a rare situation, there is dis-economy of sclae. Usually, X is the smaller than unity.

The relationship of unit costs for small plants and large plants is not linear. In fact, while there is usually a significant reduction in unit cost as plant size increases, the rate of change decreases above 10 mgd capacity and the curve may even have a reverse inflection above 100 Mgd capacity, but data are too sparse to confirm.

Where consolidation is being considered to take advantage of the economics of scale, other costs may have an effect. A small plant may require only primary treatment for land disposal or secondary treatment where the small discharge will have insignificant effect on receiving waters, whereas a large plant may require AWT or a long outfall and diffuser because of mass emissions. Also, small plants can often be located on small sites near wastewater sources, eliminating long consolidation trunk lines and extensive raw sewage pumping which is usually associated with consolidation projects.

Where existing small plant treatment facilities are not fully amortized, consolidation may result in costs in addition to the cost of new facilities.

The ratio of peak-to-average flows affects unit costs. A small plant served by separate sewers with low infiltration/inflow may be more economical than consolidation into a large system with combined sewers and high infiltration/inflow which could result in higher unit costs.

In addition to the unit costs for capital facilities, there are also unit costs for operation. Unit costs for operation of small plants, with present monitoring and control requirements, are very high, but decrease rapidly with scale. However, data indicate that little reduction occurs above a plant size of 20 mgd.

For preliminary screening of alternatives in feasibility studies and in facilities planning reports, costs are often obtained initially from tables or curves which give costs versus size. Sources are either EPA publications or the engineers' own documents. Examples include two EPA Technical Reports "A Guide to the Selection of Cost-effective Wastewater Treatment Systems", reference 7.9, and "Costs of Wastewater Treatment by Land Application", reference 7.10. Our analyses of the data presented in these and similiar documents indicate that the scale factor X is often in the range of 0.5 to 0.6 for sewers and 0.7 to 0.8 for treatment facilities when applied to capital costs. The scale factor for operation and maintenance cost is often even smaller. The effect of a smaller economy of scale factor is that the incremental or marginal cost for extra capacity, is of lower cost than if the extra capacity were provided independently. This relationship favors consolidation where it can be accomplished without adding otherwise unnecessary facilities, such as interceptors, which provide no treatment and which cost more than the savings obtained by using larger consolidated treatment facilities.

Marginal Cost (C_M) is the difference between costs for two projects divided by the difference between the given capacities, and are therefore, in units of dollars per unit measure of size. Marginal Cost (C_M) is expressed as follows:

$$C_M = C_L - C_s / Q_L - Q_s \qquad \text{(Equation 7.2)}$$

We have reviewed typical capital costs for conventional complete secondary treatment plants from reference 7.9. Marginal capital costs for various size plants were compared with plant capacity. We found the economy of scale to have diminishing returns when the capapcity was approximately 30 million gallons per day. The proposal satellite plants are of a size (25 and 31 mgd) to achieve optimum economy of scale, compared to individual plants for each community, which would be served by them. Above that size, the marginal cost does not appear to be substantially cheaper per unit of capacity.

2. STUDY AREA COSTS

a. Peripheral Area

The portion of the study area outside the proposal expanded MSD Service area is known as the peripheral area. It is comprised of fifty-eight communities, only some of which have their own sewerage systems or are participants in one of the existing regional systems.

The EMMA Report states that the possible need for sewerage service in the peripheral area can best be satisfied separately from the MDC so as not to aggravate the problems of the Deer and Nut Island systems. Costs are given as follows:

	Millions of Dollars	
	Capital Cost	O & M Cost
Peripheral Area Systems	$268.	$26.8

Year 2000 projections for the peripheral area sewer population is shown as 924,581 persons. The above reported costs are equivalent to $290 capital cost and $29.0 annual O & M per capita.

Because no time schedules or length of construction periods are available, it is not possible to determine the present worth of the above costs.

By comparison, data from the 1976 Needs Surveys (referenced in Chapter 3) give the EPA share of grants needed in peripheral area communities, as $443.9 million. Capital costs would be, assuming grants are 75 percent, $587 million or more than twice the amount given in the EMMA Report for the same area. This is equivalent to $528 per capita.

The FY 1976-77 Priority List has 42 projects in the peripheral area. This list shows 13 are on the active basic list and 29 are on the extended list. The EPA Share totals $161.2 million representing projects costs of $215 million for that year. This is equivalent of $233 per capita, using the EMMA year 2000 value for population.

b. Expanded MSD

Capital cost of the EMMA Recommended Plan, as we reported Chapter 3, is $855.4 million and would serve 2,440,000 persons in the expanded MSD. The annual operation and maintenance cost is noted as $25.6 million. We computed the present worth of the capital and O & M costs are $603.0 million in accordance with EPA guidelines, 7.87 at the January 1975 price level used in the EMMA Report.

The unit costs per capita of the EMMA recommeded plan are $350 in capital costs and $10.50 in annual O & M costs.

The unit present worth amount of the EMMA Recommended Plan would be $248. per capita or about $1,200. to serve a family dwelling.

Costs for providing MSD sewerage service to an unsewered community would presumably be $248. per capita, plus the proportionate share of the value of existing MDC facilities, plus the cost of sewers. If the communties paid a proportionate share of the cost of all MDC facilities, the cost of sewers is believed to exceed the cost of interceptors and treatement and disposal facilties.

The population now contributing sewage to MDC is estimated to be 1,980,083 persons. The unit cost of the EMMA Recommended plan based upon the existing population (the present worth) is $305. per capita. This is twenty-three percent higher than when based on predicted population because there is that percentage fewer people now.

c. Satellite Communities

Estimated costs to provide interceptors and AWT plants for the satellite communites are shown in the EMMA Recommended Plan. We have calculated the present worth of those costs. The items are identified in the EMMA Report (and in Chapter 3), as priority items 10, 14, 41 and 43 for Middle Charles River Area and as items 11, 19, 44 and 45 for the Upper Neponset River Area.

They are summarized below:

Satellite Service Area	Million Dollars Capital	Annual O&M	Present Worth
Middle Charles	$78.9	$2.8	$58.1
Upper Neponset	56.1	2.4	42.8
TOTAL	$135.0	$5.2	$100.9

The 1970 population and the year 2000 population predicted to be served by the satellite facilities are given in the EMMA Report as follows:

Satellite Service Area	Population, Thousands 1970	2000
Middle Charles	73	181
Upper Neponset	55	124
TOTAL	128	305

If the satellite communities were to provide facilities in accordance with the EMMA Recommended Plan independently of the MDC, the unit costs, based in 1970 and 2000 populations, exclusive of the sewers, would be:

	Dollars Per Person Capital Cost	Annual O&M	Present Worth
1970 Population	$1050	$41	$850
2000 Population	443	17	357

Even though these costs are greater than for average per per capita costs of the EMMA Recommended Plan, they do not include any

any amount for correction of combined sewer overflows.

3. INDIVIDUAL SYSTEMS

Costs of sewerage for a small-community consists of three basic items:

(1) Construction and maintenance of local collection sewers.

(2) Construction and maintenance of trunk sewers, and

(3) Construction, operation, and maintenance of some type of community waste treatment and disposal system.

Where cost effectiveness comparisons of alternative systems have been conducted it has been estimated that the cost of local collection sewers alone is often the most costly single component of a small-community sewerage system, according to a recent EPA Technology Transfer Seminar on Small Wastewater Treatment Systems, reference 7.11. The cost of individual septic tank systems is also noted as being approximately equal to the cost of local collection. Facilities for additional conveyance, treatment and disposal are extra.

Typical costs for individual septic systems presented in reference 7.11 for comparison with central systems are approximately as follows when converted to 1975 price levels:

Capital cost of initial septic tank installation, drain-field, and permit	$1,800.
Replacement of drain-field ten years later	$1,400.
Annual cost of maintenance including pumping and expenses of administration by a public agency	$50.

We have computed the present worth of individual septic systems two ways. In the first case we assumed all facilities would be built in the year 1980 and used until 2000, with a replacement drainfield needed in 1990. In the second case, we assumed all facilities would be built in the year 1990 and used until the year 2000. The costs are as follows:

	Capital Cost	Annual Cost	Present Worth
Case 1	$3,200	$50	$2,134
Case 2	1,800	50	955
Average	$2,500	$50	$1,545

It is noted that the MDC estimates that there is an average of 4.94 persons per sewer connection at present. The above for septic systems would be:

	Cost per Person		
	Capital	Annual O&M	Present Worth
Case 1	$650	$10	$433
Case 2	365	10	193
Average	$508	$10	$313

For an unsewered community, the apparent costs of septic tank systems, including maintenance and administration by a public agency, is approximately the same as the cost of a central treatment system. For a central sewerage system, the cost of sewers is additional.

Many citizen members of advisory committees expressed the desire for alternatives to conventional sewer systems.

D. SUMMARY OF CHAPTER 7

1. The Metropolitan Sewerage District presently collects and treats sewage from 40 percent of the area and 90 percent of the population of the District.

2. The Charles River Pollution Control District has an AWT plant under construction and plans to serve Franklin, Medway and the north part of Bellingham with a discharge in the Charles River Watershed.

3. The South Essex Sewerage District and the Lynn Regional System serve towns in the North Coastal Watershed.

4. There is an apparent desire by several communities in the Study Area to continue using individual septic systems or, if necessary, to have their own community sewerage system. The MAPC and EPA Headquarters in Washington tend to support, or at least recognize this position as worthy of further analysis.

On the other hand, MDC seems to have taken the position of desiring to offer unsewered communities sewerage service as part of a large consolidated centralized system. This view is strongly supported by EPA Region I and the State DWPC.

5. Sewer construction is said to encourage growth and sprawl, which contradicts the controlled-growth attitudes exhibited by the MAPC communities.

6. The MAPC indicates that not consolidating facilities is favored to maintain the potential for water reuse and reclamation in the satellite areas.

7. The MAPC and the 1976 Needs Survey agree that sewers are not required for four of the eight towns to be annexed to the MSD under the EMMA plan. No documented wastewater problems in these eight communities were disclosed in our research, although other towns in the Boston Harbor watershed having problems are not to be served.

There is disagreement among planning agencies as to whether communities which are presently unsewered should have their own facilities, should annex to a regional agency, or should remain unsewered.

8. There is an absence of written guidance from EPA on the need for sewers in an unsewered area and the desirability of consolidation practices. A draft PRM was prepared that would make septic tanks conditionally grant eligible, an often previously neglected alternative to sewers and treatment facilities.

9. The principle of economy of scale usually applies to wastewater treatment plants and generally favors consolidation practices where sewerage is provided.

10. The average unit present worth of estimated costs to provide individual septic systems in the satellite communities is $313 per capita. For an unsewered community, this cost is approximately the same as that of providing a central treatment system, exclusive of collection sewers.

REFERENCES

7.1 Urban Systems Research & Engineering, Inc/CEQ
"Wastewater Management Planning: Boston
Metropolitan Area, Phase 1 Study"
July 16, 1976

7.2 MDC Sewerage Division
"Fifty-Seventh Annual Report,
Fiscal Year Ending June 30, 1976"
October 14, 1976

7.3 MAPC
" '208' Interim Output I"
Preliminary, May 10, 1976

7.4 Camp, Dresser & McKee/MAPC
"Alternative Regional Sewerage
Systems for the Boston
Metropolitan Area"
October 1972

7.5 U.S. EPA
Draft of Proposed
"Construction Grants Program
Requirements Memorandum
PRM #77-___,"
"Eligibility of Septic Tanks,
and Other Small Treatment Systems"
November 9, 1976

7.6 Illinois Environmental Protection Agency,
Division of Water Pollution Control,
"Guidelines for Evaluating the
'No Action' Alternative in Small,
Unsewered Communities,"
September 15, 1976

7.7 "Septage Treatment Gets Research Help"
The American City & County,
February, 1977

7.8 Wallace, Floyd, Ellenzweig, Moore, Inc.
Arthur D. Little, Inc., and
Dr. Michael Mohr/The Commonwealth
of Massachusetts, Executive Office of
Environmental Affairs
"Massachusetts Water Supply
Policy Study"
January 1977

7.9 Van Note, et al (Bechtel Inc.)/U.S. EPA
"A Guide to the Selection of
Cost-effective Wastewater
Treatment Systems"
Technical Report, EPA-430/9-75-002
July 1975

7.10 Pound, Crites & Griffes, (Metcalf
& Eddy, Inc./U.S. EPA
"Costs of Wastewater
Treatment by Land Application"
Technical Report EPA-430/9-75-003
June 1975

7.11 Brown and Caldwell/EPA
"Cost-Effectiveness Analysis
of Alternatives for Small
Wastewater Treatment Systems"
Technology Transfer Municipal
Design Seminar on Small
Wastewater Treatment Systems,
Seattle, Washington,
March 7 to 9, 1977

CONTENTS

Chapter 8

WATER CONSERVATION

Section	Title	Page
A.	FEDERAL RULES AND REGULATIONS PERTAINING TO WATER CONSERVATION AND REUSE	8.1
	1. Availability of Grants	8.1
	2. Federal Environmental Impact Statement Requirements	8.4
B.	WATER CONSERVATION AND WASTE REDUCTION PRACTICES IN THE EMMA STUDY AREA	8.5
	1. Present Practice	8.5
	2. Future Programs	8.16
C.	POTENTIAL WATER CONSERVATION MEASURES AND THEIR EFFECTIVENESS	8.18
	1. Water Saving Devices and Appliances	8.19
	2. Non-Structural Measures	8.25
	3. Potential for Implementation of Water Conservation Measures in EMMA	8.31
D.	SUMMARY OF CHAPTER 8	8.33
	REFERENCES	8.34
Table 8-1	Water Sources and Daily per Capita Usage in MDC Communities - 1972	8.7
Table 8-2	Comparison of Water Usage in MDC Communities - 1972	8.11
Table 8-3	Household Water Uses	8.20
Table 8-4	Potential Water Savings from Residential Interior Fixtures	8.24

Chapter 8

WATER CONSERVATION

This chapter presents a discussion of water conservation and waste reduction measures which can result in decreased wastewater flows. Pertinent Federal rules and regulations are reviewed. Present water conservation practices in the EMMA Study Area are discussed. Finally, alternative water conservation measures are considered with respect to their potential for reducing wastewater flows.

A. FEDERAL RULES AND REGULATIONS PERTAINING TO WATER CONSERVATION AND REUSE

The following discussion outlines some of the major Federal rules and regulations pertaining to water conservation and reuse that could influence the development of integrated water and wastewater management programs in the EMMA Study Area.

1. AVAILABILITY OF GRANTS

The desirability of water conservation and the reuse of reclaimed water, where feasible, is encouraged by Federal laws and regulations. Section 201 of the Federal Water Pollution Control Act (PL92-500) contains a treatment works construction grant condition which states, Reference 8.1:

> "...as appropriate, the works proposed for grant assistance will take into account and allow to the extent practicable the application of technology at a later date which will provide for the reclaiming or recycling of water or otherwise eliminate the discharge of pollutants."

Section 104(o) of PL92-500 directs the EPA Administrator to investigate methods of water conservation and waste flow reduction. Paragraph 1 of this section states:

> "The administrator shall conduct research and investigations on devices, systems, incentives, pricing policy, and other methods of reducing the total flow of sewage, including, but not limited to, unnecessary water consumption in order to reduce the requirements for, and the costs of, sewage and waste treatment services. Such research and investigations shall be directed to develop devices, systems, policies, and methods capable of achieving the maximum reduction of unnecessary water consumption."

It is clear that Congress perceived the benefit in reduced sewerage system costs which may be obtained through water conservation and waste flow reduction.

The Federal Water Pollution Control Act Amendments of 1972 (PL92-500), Section 105(a)(2), authorizes the EPA Administrator to make grants to any State or municipality for the purpose of research and development of advanced waste treatment and water purification methods. Section 105(d)(2) of the Federal Water Pollution Control Act requires that the Administrator conduct on a priority basis an accelerated effort to develop, refine, and achieve practical application of advanced waste treatment methods for reclaiming and recycling water and confining pollutants so they will not migrate to cause water or other environmental pollution.

Section 1444 of the Safe Drinking Water Act of 1974 authorizes a development and demonstration program to (1) investigate and demonstrate health implications involved in the reclamation, recycling and reuse of wastewaters for drinking, and (2) demonstrate processes and methods for preparation of safe and acceptable drinking water from wastewaters, Reference 8.2.

According to the above provisions of Federal laws, funds can be granted to research and development projects for wastewater reclamation and reuse. Such funds are apparently for demonstration scale projects and are not intended to finance construction of large scale wastewater treatment and effluent disposal programs such as those being planned for the EMMA Study Area. However, these research and development grants would presumably be available for studies or demonstration projects for water conservation and reuse in the EMMA Study Area. Such studies could suggest local water conservation and reuse programs that could alter or reduce the scope of the long distance transport and centralized sewage treatment being considered for the EMMA Study Area.

With respect to Federal funding of total facilities plans, provisions of Title II of the Federal Water Pollution Control Act Amendments of 1972 make Federal grant funds available for payment of 75-percent of the eligible project cost for the construction of wastewater treatment works including reclamation facilities. Section 201(d)(3) of the Water Pollution Control Act Amendments states that the Administrator shall encourage waste treatment management which results in the construction of revenue-producing facilities providing for the reclamation of wastewater.

Appendix B to Part 35 of the Federal Construction Grant Regulations entitled "Federal Guidelines,User Charges for Operation and Maintenance of Publicly Owned Treatment Works", promulgated August 1976, include the following provisions:

a. Quantity discounts to large volume water users will not be acceptable. Savings resulting from economies of scale should be apportioned to all users or user classes, and

b. User charges may be established based on a percentage of the charge for water usage only in cases where the water charge is based on a constant cost per unit of consumption.

Thus, Federal regulations promote water conservation, reuse, and waste flow reduction by

a. encouraging the design of projects with sufficient flexibility to accommodate future water reuse opportunities,

b. funding research and development of projects to demonstrate conservation,

c. funding reclamation projects as components of grant eligible treatment works, and

d. indirectly, by prohibiting user charge discounts to large volume users.

2. FEDERAL ENVIRONMENTAL IMPACT STATEMENT REQUIREMENTS

EPA requires that its environmental impact statements on wastewater facilities consider water conservation and waste flow reduction measures. EPA's July 1974 Manual for Preparation of Environmental Impact Statements for Wastewater Treatment Works, Facilities Plans, and 208 Areawide Waste Treatment Management Plans requires that "subsystem alternatives" for "flow and waste reduction measures" be considered in the EIS in the following categories, Reference 8.3:

"a. Infiltration/inflow reduction by sewer system rehabilitation and repair and elimination of roof and foundation drains;

b. household water conservation measures, such as household water saving appliances and fixtures as well as designing more appliances for less water consumption;

c. water and wastewater rates that impose costs proportional to water used and wastewater generated and use of water meters; and

d. educating the public on the value of their water resources in order to reduce their consumption."

The consideration of flow and waste reduction measures has as its goal the benefit of reduced sizes of wastewater conveyance, treatment and disposal facilities in cases where excess flows can be cost-effectively eliminated prior to their entrance to the sewer system.

Infiltration/inflow, particularly as related to the combined sewer problem in the EMMA Study Area, is discussed in Chapter 6 of this report. The potential for wastewater flow reduction through water conservation is discussed in the remainder of this chapter.

B. WATER CONSERVATION AND WASTE REDUCTION PRACTICES IN THE EMMA STUDY AREA

As a basis for discussion of potential water conservation measures in the EMMA Study Area, certain key state and local water supply agencies and regulatory agencies were contacted to determine present practices and planning activities in the EMMA Study Area. Although not every water purveyor in the EMMA Study Area was contacted, the information presented below regarding water conservation practices in the EMMA Study Area appears representative of the present situation.

1. PRESENT PRACTICE

a. State Agencies

(1) Division of Water Pollution Control. In its review of grant applications for wastewater treatment projects, the Division of Water Pollution Control (DWPC) does not directly evaluate the existence or effectiveness of water conservation practices within a proposed project area that may influence projected wastewater flows. The DWPC does review the projected wastewater flow increases on which facility sizing will be based in order to assure that the submitted

flow projections are reasonable. In particular, DWPC project evaluators allow 1 percent per year increases in projected per capita wastewater flows, but increases greater than 1 percent per year are allowed if the applicant can show reasonable cause to believe that greater flows will occur, Reference 8.4.

(2) Executive Office of Environmental Affairs. The Executive Office of Environmental Affairs (EOEA) is presently preparing a report (to be released January 15, 1977) on state water policy which will include proposals regarding water conservation. The state water policy report is being prepared with the joint cooperation of the MDC, the Division of Water Resources, and the Division of Water Supply and Water Quality. The state water policy report will discuss water pricing mechanisms, price elasticity, and other policy matters pertaining to water conservation, Reference 8.5.

(3) Metropolitan District Commission. The Water Division of the Metropolitan District Commission (MDC) supplies water to 33 member communities and 10 non-member communities. Of the 43 communities receiving water from the MDC, 37 communities, including all 33 MDC member communities, are located within the EMMA Study Area. Six non-member communities are located outside EMMA. Data on water supplied by MDC and/or the community public source with per capita usage for 1972 for each of these 43 communities are presented in Table 8-1. Total water supplied including private sources for industries and institutions are also given, Reference 8.6.

MDC is a wholesale water supplier to the 43 communities that it supplies. The member communities are presently charged a uniform rate of $240 per million gallons, and some of the non-member communities pay less than $240

TABLE 8-1

WATER SOURCES AND DAILY PER CAPITA USAGE IN MDC COMMUNITIES 1972 (Ref. 8.6)

Community Member	Total MDC and Community Supply Gallons per Day (GPD)	Per Capita Usage GPCD Pop. Served	Total Water Supply Incl. Industrial & Institutional GPD
Arlington	6,987,000	129.	7,130,000
Belmont	2,794,000	99.	2,805,000
Boston	143,975,000	229.	213,480,000
Brookline	7,628,000	128.	7,642,000
Cambridge	22,346,000	226.	22,347,000
Canton	1.760,000	99.	2,187,000
Chelsea	3,673,000	122.	4,689,000
Everett	7,619,000	180.	14,624,000
Lexington	4,508,000	138,	4,525,000
Lynnfield W.D.	347,000	88.	391,000
Malden	7,293,000	131.	7,656,000
Marblehead	2,136,000	98.	2,162,000
Medford	8,551,000	133.	8,551,000
Melrose	2,916,000	86.	3,387,000
Milton	2,262,000	83.	2,291,000
Nahant	407,000	98.	407,000
Needham	3,219,000	105.	8,028,000
Newton	11,597,000	127.	11,867,000
Norwood	5,132,000	160.	5,137,000
Peabody	6,245,000	123.	9,320,000
Quincy	10,497,000	119.	10,693,000
Revere	3,533,000	81.	3,534,000
Saugus	2,829,000	110.	2,894,000
Somerville	11,004,000	126.	11,004,000
Stoneham	3,337,000	157.	3,441,000
Swampscott	1,513,000	111.	1,519,000
Wakefield	3,514,000	138.	3,664,000
Waltham	11,038,000	176.	11,275,000
Watertown	4,542,000	115.	4,565,000
Weston	1,085,000	105.	1,150,000
Winchester	1,995,000	87.	2,985,000
Winthrop	1,830,000	90.	1,831,000
Woburn	4,763,000	123.	8,933,000
	312,878,000	164. Average	406,018,000
Non-Members			
*Chicopee	12,607,000	187.	14,785,000
*Clinton	3,161,000	235.	3,827,000
Framingham	7,664,000	113.	7,818,000
*Leominster	8,121,000	243.	9,940,000
Marlborough	3,365,000	114.	3,383,000
Northborough	616,000	75.	691,000
Southborough	402,000	73.	435,000
*S. Hadley	1,603,000	129.	2,603,000
*Wilbraham	792,000	92.	1,012,000
*Worcester	25,526,000	147.	61,599,000
	63,858,000	152. Average	106,093,000
Totals	376,736,000	161.	512,111,000

*Communities located outside of the EMMA Study Area.

because they are located west of the metropolitan area and closer to MDC water supply reservoirs in central Massachusetts. MDC supplies water only to public agencies with the sole exception of a special contract to supply water to the General Electric plant in Lynn, Reference 8.7. The MDC supplies wholesale water to the 43 user communities through more than 200 metered connections between the MDC water supply system and the community distribution systems, Reference 8.7. The communities purchasing water from the MDC receive an annual bill from the MDC in November for water purchased in the previous year, i.e., 1975 usage is billed in November 1976.

The MDC has no control over the water prices or rate structures utilized by the communities that rely entirely or partially on MDC water. Water rates for consumers in each community are determined by each community's water board, water commission or superintendent, or city council, Reference 8.8. Most communities add their operating costs to the MDC purchase price for water and bill their customers accordingly, commonly using a declining block rate structure, Reference 8.9.

The state laws, under which the MDC operates, do require that all customers receiving water from agencies that utilize MDC water for supply must be metered and billed according to their usage. Chapter 92, Section 28 of the Massachusetts General Laws states, Reference 8.10.

> "All towns, districts or corporations which derive all or any part of their water supply from the metropolitan system or from sources used by or under the control of the commission shall equip with water meters all water services installed for them, and shall also annually equip with water meters five percent of the water services which were unmetered on

> December 31, 1907, until all are metered; and shall charge each consumer having a meter service in proportion to the amount of water used; provided that no town or district shall, in any one year, contract for more than the number of meters to be installed by it during that year under this section; and provided, also, that a minimum rate may be fixed for which the consumer shall be entitled to a stated quantity of water."

However, there is still a significant quantity of MDC water that, after delivery to individual communities, is utilized or lost without metering.

In June 1975, a report entitled "Metropolitan District Commission Water Usage Study" was completed, Reference 8.6. This study investigated the 1972 usage of water supplied by MDC, as well as supplementary community-owned supplies, in the 43 communities that receive MDC water. Based on the assumption that the master meters of the MDC and community-owned supplies were accurate, the MDC Water Usage Study categorized water consumption in each community according to domestic, commercial, industrial, public and unmetered usage for the year 1972. Water supplied by MDC and/or the communities averaged 377 mgd of which 131 mgd (35%) was unmetered (exclusive of another 135 mgd from private water supplies). Water use percentages for the various categories are presented in Table 8-2, Reference 8.6.

Reported average water use supplemental to Table 8.2, was as follows, in million gallons per day.

a. Domestic	125
b. Commercial	44
c. Industrial	50
d. Public	26
e. Unmetered	131
Total Public supplied	377

Total Public supplied	377 (carried forward)
f. Private supplied	135
Total Water Use	512

The data presented in Table 8-2 show that of the 43 communities studied, 28 had unmetered water usage in excess of 20 percent of the total MDC and community-owned supply. The category of unmetered water usage includes such possible uses as distribution system leaks, breaks and unavoidable leakage, meter slippage, blow-offs, main flushing, sewer flushing, street cleaning, firefighting, unmetered public usage and other unmetered usage (such as illegal use of hydrants). It was noted that approximately one-half of total unmetered usage in all 43 communities occurred in the City of Boston.

The 1975 MDC Water Usage Study recommended the following, Reference 8.6:

> "1. Urge the City of Boston to undertake a study to determine the basis of the reasons for its extraordinarily high unmetered water usage, particularly in the subcategories: 'distribution system leaks, breaks and unavoidable leakage, meter slippage, blow-offs, main flushings, sewer flushing, street cleaning, fire-fighting, unmetered public usage, and other unmetered usage.'
>
> 2. Encourage communities to initiate programs of leakage detection and repair where such leakage exceeds 3000 gallons per mile of main per day.
>
> 3. Evaluate and, if necessary, strengthen its master meter maintenance and operation program.
>
> 4. Evaluate the meter maintenance and operation programs of the communities it serves, and set forth the basic elements of a model community meter maintenance and testing program.

TABLE 8-2

COMPARISON OF WATER USAGE IN MDC COMMUNITIES - 1972 (Ref. 8.6)

(From MDC and Community-owned Supplies-Excludes Private Sources)

	PER CENT USE				
Community	Domestic	Commercial	Industrial	Public	Unmetered
Arlington	46.	2.	0.	1.	51.
Belmont	64.	4.	4.	5.	24.
Boston	17.	19.	9.	9.	46.
Brookline	68.	6.	1.	8.	18.
Cambridge	21.	9.	15.	16.	38.
Canton	58.	14.	2.	4.	22.
Chelsea	57.	8.	1.	7.	27.
Everett	33.	4.	47.	1.	14.
Lexington	65.	4.	5.	5.	20.
Lynnfield W.D.	48.	16.	0.	0.	35.
Malden	45.	4.	4.	3.	44.
Marblehead	56.	6.	0.	6.	32.
Medford	40.	4.	4.	3.	50.
Melrose	50.	2.	10.	3.	34.
Milton	74.	3.	0.	8.	15.
Nahant	67.	5.	0.	0.	28.
Needham	65.	13.	2.	2.	18.
Newton	54.	8.	6.	6.	26.
Norwood	35.	6.	17.	2.	40.
Peabody	47.	9.	20.	1.	23.
Quincy	46.	6.	13.	1.	35.
Revere	70.	7.	6.	0.	18.
Saugus	44.	13.	0.	1.	43.
Somerville	39.	6.	9.	3.	44.
Stoneham	28.	7.	26.	3.	36.
Swampscott	62.	6.	0.	1.	31.
Wakefield	39.	9.	28.	0.	25.
Waltham	37.	5.	36.	4.	17.
Watertown	44.	11.	11.	7.	27.
Weston	66.	3.	0.	9.	21.
Winchester	62.	12.	0.	8.	18.
Winthrop	72.	4.	3.	5.	15.
Woburn	58.	6.	5.	2.	29.
MEMBER AVERAGE	32.	12.	10.	7.	38.
Non-Member					
*Chicopee	45.	3.	34.	10.	7.
*Clinton	20.	3.	14.	1.	62.
Framingham	51.	9.	17.	11.	11.
*Leominster	34.	5.	51.	1.	9.
Marlborough	43.	7.	13.	3.	34.
Northborough	59.	14.	5.	4.	18.
Southborough	58.	13.	9.	9.	12.
*S. Hadley F.D.1	65.	2.	32.	1.	0.
*Wilbraham	55.	7.	18.	9.	11.
*Worcester	33.	12.	24.	7.	24.
NON-MEMBER AVERAGE	33.	8.	27.	7.	13.
AVERAGE	33.	12.	13.	7.	35.

*Communities located outside of the EMMA Study Area.

> "5. Request communities to submit an annual summary of water usage including:
>
> (1) total metered water as recorded on consumer meters;
>
> (2) total unmetered usage;
>
> (3) detailed breakdown of unmetered water usage (as shown in Table 8-2) if the amount of unmetered water exceeds a specified percentage, e.g. 20 percent.
>
> 6. Evolve and apply a long-term education program directed to promotion of water savings among consumers.
>
> 7. Initiate a study to provide further information on the price elasticity of water use."

MDC distributed copies of the MDC Water Usage Study to all the communities that utilize MDC water, which has prompted various actions by the individual communities, Reference 8.11. Communities, such as Boston and Chelsea, have increased their leak detection programs. Some communities, such as Newton and Brookline, have experimented with water conservation education programs in local schools. The MDC presently has no formal programs of its own to promote water conservation by the means of public advertisements or the distribution of educational materials pertaining to water conservation methods and devices. The MDC has submitted legislation for appropriation of funds to pursue programs suggested by the Water Usage Study; however, the proposed legislation was not adopted by the State Legislature in its last session, Reference 8.11.

(4) Department of Public Utilities. The Massachusetts Department of Public Utilities (DPU) oversees the activities of private water, gas and electric companies and other privately owned utilities in accordance with Chapter

165 of Massachusetts General Laws.

All private water purveyors must have their rates approved by the Commissioners of Public Utilities. The rates are determined according to the expenditure and financial planning information submitted to the Department. The DPU does not require any particular rate structure, i.e., flat rate (unmetered), declining block or uniform rate, because each company is considered on a case by case basis with regard to the financial information submitted.

It was reported that there are no state laws requiring water meters on service connections to private water companies; however, most companies require metering for billing purposes, Reference 8.12.

The DPU does not require water companies to maintain water conservation education programs, nor does the DPU require any special programs for the promotion of water saving household devices, Reference 8.12.

b. Municipal Agencies

(1) City of Boston. The City of Boston purchases all of its water from the MDC. The City of Boston utilizes approximately 144 million gallons per day according to the 1972 data presented in Reference 8.6.

Although the City of Boston had a large part (46%) of its water in the unmetered usage category discussed above, Boston ordinances require all service connections to be metered, Reference 8.13. All industries receiving water from the City of Boston are metered, with meters on connections larger than 2-inch paid for by the user. Some public buildings and private residence are not metered; for example, some residences have had meters removed to increase water pressure, Reference 8.13. The Boston Public Works Department has an on-going program for the detection and repair of leaks in the city's distribution system.

The Boston City Council determines the city's water rate. The City of Boston presently has a declining block rate structure that charges $7.65 per 1000 cubic feet for the first 80,000 cubic feet per year, $6.25 per 1000 cubic feet for 80,000 to 4 million cubic feet per year, and $4.60 per 1000 cubic feet in excess of 4 million cubic feet per year.

The City of Boston presently has no programs to promote water conservation through public education nor any programs to provide water-conserving devices for household use, Reference 8.13.

(2) Old Colony. The Old Colony planning area is located adjacent to the EMMA Study Area's southern boundary. The Old Colony area consists of 10 towns around Brockton with a total population of approximately 200,000 people. Although the Old Colony area is not within the EMMA Study Area, some of the water conservation actions taken there are of interest as a sampling of water conservation practices that may be feasible in the EMMA Study Area also.

Some of the communities in the Old Colony area have experienced water shortages in recent years, particularly during summer months. Six of the communities are supplied solely by wells, while three others plus Brockton have surface water supplies supplemented by wells. Brockton has a water filtration plant. The water systems in the area are publicly owned and operated by the individual communities.

Water meters are required for all customers, although a few summer homes are not metered. Most communities including Brockton have declining block rate structures, but the town of Abington has recently changed to a uniform rate for all customers, including industry, Reference 8.14.

Some of the communities in the Old Colony area have advertised the need to conserve water. During the summer, newspaper advertisements are used to announce water use restrictions, such as limitations on lawn watering.

As of yet, there have been no programs for the distribution of household water-saving devices in the Old Colony communities. However, a recently completed environmental impact assessment of the 201 Facilities Plan for a proposed wastewater treatment plant for the Town of Avon contains a mitigation measure which would require the use of water-saving devices and appliances in new construction, Reference 8.14. Local residents are concerned that the new sewerage system will induce local development which could worsen current water supply problems. At present, the Avon water superintendent reviews all new water connection applications which must project expected water use. Local planners are currently reviewing the State Plumbing Code (Chapter 142, Section 13 of Massachusetts General Laws), which may be interpreted to allow towns to require water-savings devices in new construction for water conservation purposes, Reference 8.14.

c. Private Water Companies. Although most communities in the EMMA Study Area have public water systems, a few private water companies do exist. One such company was contacted to learn what private water companies in the area are doing presently with regard to water conservation.

(1) Dedham Water Company. The Dedham Water Company supplies water to approximately 50,000 residents of the communities of Dedham and Westwood, both of which are within the MDC Southern Sewerage System tributary to the Nut Island Treatment Plant. The Dedham Water Company has approximately 11,300 connections,

all of which are metered. Ninety-five percent of the connections are residential services, and the remaining five percent are commercial and industrial services. The water supply is from local wells.

The Dedham Water Company has a declining block rate structure. The rate structure is approved by the Massachusetts Department of Public Utilities.

The Dedham Water Company presently has no programs to promote water conservation through public education nor any programs to provide water-conserving devices for household use, Reference 8.15.

2. FUTURE PROGRAMS

(a) Executive Office of Environmental Affairs. As mentioned previously, the EOEA is now preparaing a state water policy report. It is anticipated that policy recommendations included in this report will ultimately produce new state programs concerning water conservation.

(b) Metropolitan District Commission. The MDC will continue to encourage water conservation by its member communities. MDC plans to resubmit proposed legislation for appropriation of funds to implement water conservation programs suggested by the MDC Water Usage Study, Reference 8.11.

(c) State Legislation. Presently, there appears to be no pending state legislation with regard to water conservation or wastewater reuse in the State of Massachusetts, References 8.16 and 8.17.

(d) Metropolitan Area Planning Commission. The Metropolitan Area Planning Commission (MAPC) is the designated 208 planning agency for the Metropolitan Boston Area. The MAPC is now studying the development and protection of groundwater within the MAPC study area, but the MAPC has no specific programs concerning the promotion of water conservation, Reference 8.18.

(e) EMMA Study. We have reviewed the EMMA Study reports in Chapter 3. Certain alternatives investigated in that study are considered to constitute efforts toward a water reclamation program.

Technical Data Volume 5 entitled "Land Oriented Wastewater Utilization Concept" is a study directed by the Corps of Engineers to determine the feasibility of land application as a waste management technique. Designated concept 5, a portion of the wastewater would be given secondary treatment, conveyed long distances and applied to the land. (Twenty-four communities would be served by treatment plants at Deer Island and Nut Island). This concept ranked last because of highest capital cost and least preference in technical and environmental factors. Lack of local suitable sites requiring large conveyance costs contributed to the rejection of this concept. Use of sludge as a soil conditioner on land is acknowledged in the EMMA Main Report. Sludge management alternatives however were developed only for incineration (with or without other solid wastes), and no alternative was presented which would conserve this resource by utilizing sludge as a soil conditioner.

Wastewater reclamation and reuse to augment low river flows was studied in various alternative concepts. One project to supplement the flow in the Aberjona River (tributary to Upper Mystic Lake) was studied. This project was rejected as too expensive compared to other sources of water for flow augmentation even considering that other alternatives would not be eligible for clean water grant funding.

The two satellite treatment plants proposed in the EMMA Recommended Plan are substantially for the purpose of water reuse. Implementation of these two satellite plants will also result in smaller conveyance facilities and enable a smaller expansion of the Nut Island treatment plant. These two satellite plants were estimated to have $17.1 million extra capital cost and $4.7 million extra annual operation and maintenance cost compared to a program which would not have the satellite plants. This is designated as an option in the Recommended Plan. It is undetermined whether one or both of the satellite plants will survive the EIS and facilities planning process. The satellite plant alternative is reviewed further in chapter 10 of this report.

C. POTENTIAL WATER CONSERVATION MEASURES AND THEIR EFFECTIVENESS

The following discussion presents a brief description of some of the various water conservation practices that have been tested or are being investigated by water supply agencies and water resources management researchers elsewhere in the United States. Emphasis here is placed on indoor household water conservation measures that can result in reduced wastewater flows to sewerage systems. Although much research is being done on ways to reduce agricultural and landscape water uses, such reduction does not normally produce reduced sewage flows (except for the possibility of reduced surface runoff to combined sewers). Also, water-saving technology for industrial processes is not discussed because of the complex and specific nature of industrial water use; however, as will be mentioned, pricing changes can influence industrial water consumption.

Before describing various household water conservation methods, it is desirable to know which areas of household water consumption present the greatest opportunity for conservation. Although various authors have used slightly different estimates, EPA researchers have suggested the distribution of household water use shown in Table 8-3, Reference 8.19. Toilet flushing is the major single household water use and is, therefore, a prime target for water conservation as well as wastewater flow reduction efforts. Bathing and laundering are other areas of potentially significant water conservation.

1. WATER SAVING DEVICES AND APPLIANCES

Water saving devices are fixtures, attachments, inserts or new systems which simply require less water to do the same job. Use of water saving devices rarely requires any significant alteration of consumer life style or personal habits and, therefore, are quickly acceptable, Reference 8.20. Residential water saving devices can be appropriate for retrofit into existing homes and offices or be suited to new development where least cost installation can normally be achieved, or sometimes both.

The following list of water saving devices and appliances is representative of the types of devices that are presently available.

a. Low-Flush Toilets. Conventional toilets use from 5 to 7 gallons per flush. Shallow trap design or so-called low-flush toilets are now offered by most toilet manufacturers, with most using about 3-1/2 gallons of water per flush. The low-flush toilets have a smaller water tank but are otherwise identical in appearance to conventional units. Low-flush toilets are now required by code for new construction in some areas of the country, including the Washington Suburban Sanitary Commission in Maryland; Fairfax County, Virginia; and the State of California after January 1, 1978, Reference 8.21.

TABLE 8-3

HOUSEHOLD WATER USES (Ref. 8.19)

Use Category	Percent of Total Household Water Use
Toilet Flushing	27-45
Bathing	18-36
Laundering	18
Kitchen	13
Lavatory	4
Utility Sink	2

b. Toilet Tank Retrofit Devices. Toilet dams or displacement devices have been developed principally for installation in existing toilets. These devices include inserts to dam off part of the toilet tank or plastic bottles to displace water in the tank. Experience has shown these devices to achieve between 1/2 to 1 gallon of water saved per flush, Reference 18.20. The Washington Suburban Sanitary Commission has distributed to its customers approximately 890,000 plastic quart bottles in the form of "bottle kits" for the displacement of water to reduce flush volumes in existing toilets, Reference 18.22. (Toilet leak-detecting dye tablets were also included in this "bottle kit" package). Displacement devices have become widely used in the West.

c. Low-Flow Shower Heads. Common shower heads now in use deliver about 6 gallons per minute (gpm) or some up to 12 gallons per minute. However, low-flow shower heads or plastic in-line inserts are now available which can limit shower flow rates to 3 gallons per minute, or less. 400,000 of these devices have been distributed by the Washington Suburban Sanitary Commission, Reference 8.22.

d. Low-Flow Faucets. Common kitchen and lavatory faucets have flow rates of approximately 4 to 5 gallons per minute. Simple faucet flow control devices can be inserted into existing faucets on flow lines to reduce the flow rate. There are a wide range of delivery rates available, ranging from 1/2 gpm to 4 gpm. The common fine mesh screen aerator, usually thread mounted on the ends of faucets, is an effective water saving device also.

e. Pressure Reducing Valves. In cases where it is known that water is wasted by excessive pressure, particularly pressures in excess of the Uniform

Plumbing Code recommended maximum of 80 pounds per square inch, pressure regulating devices may be installed in individual households or on lines serving groups of households. Reduced pressure results in lower flow rates.

f. Hot Water Pipe Insulation. Often water is wasted while the user waits for hot water to appear after the hot water faucet is opened. Insulating hot water piping which is located in attics, garages, crawl spaces or unheated spaces other than between floors or in interior walls could reduce water wastage, as well as save energy. Hot water pipe insulation, other than on a minor scale, is probably only practical in new construction.

g. Clothes Washers and Dishwashers. For the same load, some automatic clothes washers use 70 percent less water than others. Some dishwashers use 50 percent less water than others. Water savings up to 37 gallons for clothes washers and up to 8-gallons for dishwashers are possible, Reference 8.23. Although retrofitting of older machines is not practical, consumers should be made aware of the water efficiency of the washers on the market.

h. Specialty Water Saving Systems. The devices mentioned above are generally compatible with common plumbing. However, many special systems have been developed which either replace traditional plumbing or substantially modify it. These systems are mentioned here for the sake of completeness although it is doubtful that these systems will significantly alter water use in the EMMA study area in the near future.

(1) Air/Water Shower System. A shower head has been designed in which air is mixed with the water spray. Dramatic water reductions are possible. Satisfactory showers are possible using water flow rates of 1/2 gpm. This

item will produce 4 percent as much wastewater as does most old fashioned shower heads.

(2) Compressed Air Toilet. Compressed air toilets similar to those used on trains are available for home use. These toilets require about 1/2 gallon of water per flush and compressed air at 60 psi.

(3) Vacuum Flush Toilet. This system operates with a negative pressure of about 1/2 atmosphere to create slug flow to a central collection tank. Due to the need for vacuum pumps and collecting tanks, vacuum toilets are presently limited to multiple unit developments. Water requirements are about 1/2 gallon per flush.

(4) Waterless Toilets. Various waterless, self-contained toilets are now on the market. These systems include chemical toilets and composting toilet systems. With respect to the latter, the Massachusetts Division of Environmental Quality Engineering (DEQE) has approved experimental variances for the purpose of allowing test installations of composting toilet systems, Reference 8.24.

i. Effectiveness of Water Saving Devices. Preliminary data on the effectiveness of many of the devices mentioned here are now available. The Washington Suburban Sanitary Commission has conducted significant field tests of devices such as toilet tank displacement devices, pressure reducing valves and low-flow shower heads, Reference 8.22. Other agencies and researchers are expanding the data on these and other devices, Reference 8.25. Table 8-4 presents a summary of the percentage reduction in total interior water use for some water-saving devices, as recently reported by the California Department of

TABLE 8-4

POTENTIAL WATER SAVINGS FROM RESIDENTIAL INTERIOR FIXTURES (Ref. 8.23)

Fixture/Action	Water Use		Percent Savings Total Interior		Incremental Cost		In-House Energy Savings
	Standard	Improved	New	Retro	New $	Retro $	
Tank toilet	5-7 gallons per flush	3.5 gallons per flush	10-18	10-18	\$0-\$10	\$0-\$6	No
Shower	Up to 12-gals. per minute	3.0 gals. per minute	9-12	9-12	\$0-\$5	\$1-\$5	Yes
Kitchen and lavatory faucets	Up to 5-gals per minute	1.5 gals. per minute	0-2	0-2	\$0-\$5	\$1-\$5	Yes
Pressure reducing valves	80 pounds per square inch	50 pounds per square inch	0-10	0-10	\$0-\$25	\$25	Yes
Hot water pipe insulation	Not insulated	Insulated	1-4	0-1	\$0.50-\$1.00 per foot	\$0.50 per foot	Yes
Automatic clothes washer	27-54 gals. per load	16-19 gals. per load	0-5	-	\$20-\$30	Not practical	Yes
Automatic dishwasher (one load per day)	7.5-16 gals. per load	7.5 gals per load	0-4	-	0	Not practical	Yes
TOTAL			20-55	19-43			

Water Resources. Achievement of more than the stated water savings of up to 55% in new construction and up to 43% in existing buildings can result if successful education of the public to further conserve water by turning off faucets when not actually in use, to wash only full loads, etc., Reference 8.23. It is worth noting that in addition to conserving water and reducing sewage flows, most of these devices also reduce energy consumption for hot water heating.

2. NON-STRUCTURAL MEASURES

The devices discussed above are designed to reduce water use and resultant sewage flow without altering consumer habits. Non-structural water conservation measures are also being evaluated.

The primary function of water agencies has traditionally been the supply of water to consumers at whatever level the consumers demand. Thus, per capital consumption continues to increase, and water agencies study alternative methods of meeting the demand, i.e., development of new sources, increased pumping capacity, increased storage capacity, and increased treatment capacity. However, it is becoming obvious that there is need to conserve water, conserve energy, reduce wastewater flows and conserve natural resources. Just as there are national efforts being directed at reducing consumer demand for energy, similar efforts aimed at reducing consumer demand for water also appear justified. The institutional measures discussed below are representative of the approaches that may be taken to influence consumer demand for water.

a. Pricing and Metering. Pricing policies have traditionally been developed to provide revenue to satisfy capital and operating expense of the water agency, which supplies water commensurate with consumer demand. However, demand management through pricing is now being investigated and reported in the literature, References 8.23 and 8.25. In addition to providing sufficient revenue to offset all costs, water pricing structures should be equitable and discourage waste.

(1) Metering. Before discussing some alternative rate structures, the impact of water metering should be mentioned. The key to an effective water pricing policy from the standpoint of conservation is to make it clear to the user that he can save money by minimizing water use, Reference 8.23. Thus, it is important that each consumer knows how much water he is using and that he is billed according to his use. One study of the impact of water metering in California indicated that metering alone could produce a 30 percent overall reduction in residential water use and a 15 percent decrease in sewage flows compared to unmetered homes, Reference 8.26. All except one of the rate structures discussed below require metering.

Fortunately, as discussed in the preceding section of this chapter, water metering appears common in the EMMA Study Area, either because of legal requirements such as those of the MDC or for management purposes of private water companies. As noted in the MDC Water Usage Study, there still are considerable quantities of unmetered water being used in the Study Area, and identification and reduction of unmetered water usage is appropriate.

Also, before discussing various rate structures, it should be noted that most water agencies charge connection fees to cover the costs of metering devices and connections to water mains. Many agencies also have a basic minimum service charge as part of each monthly or quarterly bill. The service charge is collected to cover the operating expenses associated with meter readings and other billing expenses. In cases where these service charges are levied separately from charges for the quantity of water used, the latter more closely reflects the actual cost of the water consumed while the former accounts for some of the differences between large and small users associated with economies of scale.

(2) Flat Rate. Flat rate pricing for a given period of time is usually found in unmetered areas and consists of a flat or constant charge per unit time irrespective of the quantity of water used. This rate is considered inequitable and encourages waste because the consumer pays less per unit used as he increases his usage to a point where the marginal price of the water is zero.

(3) Declining Block Rate. Declining black rate pricing consists of a series of charges per unit of consumption which decrease as total consumption increases. This is the most common rate structure; however, it has the drawback of penalizing the smaller users who pay the expensive rate. The rate structure does not discourage increased water use because the unit price of water decreases as consumption increases. There is argument for this rate structure because of economies of scale associated with supplying large consumers. However, the declining block rate structure does not reflect the fact that water supplies are limited and that new increments of supply are more costly to develop.

(4) Uniform Rate. With a uniform rate structure, each unit of

water volume costs the same. This rate structure is considered equitable in that users pay more or less according to use, and all users pay the same unit rate. A uniform rate actually does not encourage or discourage water waste, but, when switching from a declining block rate to a uniform rate, the unit price increase for large water users may induce reductions in water use.

(5) Increasing Block Rate. The increasing block rate consists of a base charge for an initial quantity of water followed by stepwise increases in the unit charge for succeeding quantities, or blocks, of water usage. The increasing block rate structure discourages waste, but is today normally only employed when water shortage conditions exist. It would be possible to make a distinction between user classes, if necessary, but all users would pay an increasing unit price for increased use of water.

(6) Peak Load or Seasonal Rate. The peak load or seasonal rate method of pricing is intended to decrease water use during periods of maximum demand. A uniform rate is developed based on average household use during non-peak periods. During peak water use periods, a higher unit price is charged for the quantities of water used in excess of the base allotment.

The seasonal rate is normally used to conserve water during the summer months. During the summer, most water use above the base allotment is for outside uses such as lawn irrigation. Thus, while a seasonal rate may reduce outside water use, the seasonal rate would not be expected to significantly reduce sewage flows.

Application of peak rates to diurnal peaks in water use is presently not feasible because of the complex water metering and billing requirements.

b. Education. Education about water conservation should not be considered a means to an end by itself; however, education is essential in conjunction with more direct water conservation methods. The consumer should be made aware of the value of water resources and the need, economic and otherwise, to conserve water. The consumer should be informed about the costs of water supply and wastewater treatment. Consumers should be made aware of the availability of water saving devices and leak detection and repair methods that are easily employed. Such education would not only reduce water wastage in the short-run, but it would make users more receptive to more direct measures such as changes in plumbing codes to require water saving devices or changes in water rate structures. Another educational technique is to show average daily water use on the bill for the billing period, and for the same billing period one year earlier and the difference, hopefully, in water saved. Some water agencies in the United States are presently enclosing water conservation pamphlets along with their routine billing statements. Some agencies distribute pamphlets in more than one language. These pamphlets discuss topics such as:

- energy and water use
- general water consumption facts and figures
- emergency water shut-off procedures
- home irrigation tips
- leak detection and repairs
- personal water wasting habits
- water closet trouble shooting
- use of dye tablets for toilet tank leak detection

- water conserving plants
- water metering
- water saving devices
- water use and the environment

More vigorous advertising campaigns are possible, although often used only during times of water shortage. These methods include newspaper ads and television and radio commercials. The Washington Suburban Sanitary Commission has developed a 20-minute, 16 mm color film on water conservation methods entitled "Drip", Reference 8.22.

Perhaps the most important long range approach is educating school-age children about the need and methods of water conservation. Such education could be presented as an overall program about the wise use of all natural resources. Speakers' bureaus could be formed to bring discussions, demonstrations and films to the schools. Poster and water conservation idea competitions could be sponsored.

Agencies are also distributing kits free of charge to their customers. In addition to educational materials, kits include actual devices such as flow restricters to insert in plumbing fixtures, leak detection pills and displacement bottles for toilet tanks, as well as decals that serve as reminders to wash only full loads of clothes and dishes, etc.

In any case, education of consumers will be a necessary counterpart of any program hoping to achieve significant reductions in consumer demand for water.

3. POTENTIAL FOR IMPLEMENTATION OF WATER CONSERVATION MEASURES IN EMMA

The preceding discussion of water conservation measures is essentially a shopping list of measures that have been implemented or are being considered by various water agencies in the United States. Most of these measures are presently used only in areas of water shortage. Some of the water conservation measures may not be implementable in the EMMA Study Area. However, the time has come, within EMMA and elsewhere in the country, for more coordinated water supply and wastewater treatment programs, which should include appropriate water conservation measures.

a. Metropolitan District Commission Member Communities. Many of the communities within the EMMA Study Area are members of the MDC. These communities contain the majority of the population of the EMMA Study Area. Because the MDC is the wholesale supplier of both water and wastewater services to many communities, the MDC is in a particularly good position to coordinate water and wastewater programs.

The MDC has already taken initial steps toward water conservation with preparation of the 1975 MDC Water Usage Study. As a result of that study, MDC has improved meter maintenance and leak detection programs and encouraged its member communities to do the same. The MDC Water Usage Study also recommended long-range water conservation measures such as consumer education, studies of the impact of water price changes on water use, and greater accountability for unmetered water usage by member communities.

Modified price structures, particularly as they may affect industry, will require careful evaluation considering the present concern about keeping industry in the Boston area and reducing unemployment. However, the MDC should be able to proceed with water conservation education programs, as well as working with member agencies to reduce unmetered water use. The cost of the recommended EMMA wastewater treatment and disposal facilities should provide the MDC and its member communities with additional cause to find effective water conservation measures that will also pay off in reduced sewage flows.

b. Areas Outside the MDC. Implementation of water conservation measures in communitites within the EMMA Study Area but outside the MDC may require broader State programs. The statewide water policy report being prepared by the Executive Office of Environmental Affairs should provide guidance.

For private water companies, it may be necessary for the Department of Public Utilities to develop water conservation criteria with which private companies must comply before the DPU will approve private companys' water prices.

c. The Role of the U.S. EPA. The United States Environmental Protection Agency requires that EMMA communities comply with certain grant conditions prior to EPA's release of construction grant funds. The grant conditions could require good-faith efforts on the part of the communities to develop water conservation programs aimed at reducing sewage flows. The Environmental Impact Statement to be prepared by EPA on the EMMA projects should contain proposed mitigation measures to accomplish water conservation and wasteflow reductions, Reference 8.3.* These mitigation measures could also suggest suitable grant conditions.

Another action that could be taken by EPA would be to limit the grant eligible basic size of facilities to an arbitrary amount reflecting prudent water conservation practices with 100 percent local financing required for optional larger size facilities on a pro rata basis.*

---

* (The August 1978 draft EIS states: Water conservation should be employed, but the same amount of sewage is planned for as in the EMMA Report.)

We find no provisions in Massachusetts water policies nor in Clean Water Grant Regulations which would place extra emphasis on sewage reduction or wastewater reclamation programs.

D. SUMMARY OF CHAPTER 8

1. Little or no consideration seems to have been given so far to implementing programs in the Study Area that would reduce the amount of wastewater from residential, commercial and industrial establishments and, therefore, allow smaller size wastewater facilities.

2. The potential exists for new homes and office buildings plumbed with fixtures on the market today to realize a saving of up to one-half the domestic water used at present. Retrofitting existing construction can result in a domestic water saving of up to one-third. Other techniques are also available which can effect reductions in the quantity of water used and wastewater produced in other types of sources.

3. The direct benefits of total water resources management can result not only in the need for smaller wastewater facilities but in smaller water supply facilities as well, together with the need to divert less water at the source thereby allowing more natural runoff to remain in rivers and streams.

4. The issue developed in this chapter is whether the grant eligible size of wastewater facilities should be limited to a certain per capita flow consistent with appropriate water conservation and waste flow reduction measures.

---

* (Such action was taken by EPA September 27, 1978.)

REFERENCES

8.1 "Federal Water Pollution Control Act Amendments of 1972", Public Law 92-500, October 18, 1972.

8.2 "Safe Drinking Water Act of 1974", Public Law 94-523, December 16, 1974.

8.3 "Manual for Preparation of Environmental Impact Statements for Wastewater Treatment Works, Facilities Plans, and 208 Areawide Waste Treatment Management Plans", U. S. Environmental Protection Agency, July 1974.

8.4 Telephone conversation with Mr. Glen Haas, Engineer, Massachusetts Division of Water Pollution Control, Boston, October 27, 1976.

8.5 Telephone conversation with Ms. Julia O'Brien, Planner, Executive Office of Environmental Affairs, Boston, November 29, 1976.

8.6 "Metropolitan District Commission Water Usage Study", Water Resources Research Center, University of Massachusetts, Amherst, Massachusetts, June 1975.

8.7 Conversation with Mr. James Matera, Chief Engineer, Metropolitan District Commission Water Division, Boston, November 1, 1976.

8.8 Chapter 92, Section 27, of the Massachusetts General Laws.

8.9 Telephone conversation with Ms. Julia O'Brien, Planner, Executive Office of Environmental Affairs, Boston, October 27, 1976.

8.10 Chapter 92, Section 28, of the Massachusetts General Laws.

8.11 Telephone conversation with Mr. James Matera, Chief Engineer, Metropolitan District Commission Water Division, Boston, November 29, 1976.

8.12 Telephone conversation with Mr. Raymond Boulay, Engineer, Massachusetts Department of Public Utilities, Boston, November 8, 1976.

8.13 Telephone conversation with Mr. William Hannigan, Engineer, Boston Public Works Department - Water Division, Boston, November 8, 1976.

8.14 Telephone conversation with Mr. John Goldrosen, Planner, Old Colony Planning Agency, Brockton, Massachusetts, November 10, 1976.

8.15 Telephone conversation with Mr. Van Dyke, Office Manager, Dedham Water Company, Dedham, Massachusetts, November 15, 1976.

8.16 Telephone conversation with Mr. Leo Allen, Staff Assistant to Massachusetts Senator William M. Bulger, Boston, October 27, 1976.

8.17 Telephone conversation with Mr. Harry Greenwald, Staff Assistant to Massachusetts Senator Alver, Boston, November 10, 1976.

8.18 Telephone conversation with Mr. John R. Harrington, Metropolitan Area Planning Council, Boston, October 27, 1976.

8.19 "Conserving Water at Home", Dr. Harry Bostian, U.S. EPA, News of Environmental Research in Cincinnati", November 9, 1973.

8.20 "North Marin's Little Compendium of Water Saving Ideas", North Marin County Water District, Novato, California, August 1, 1976.

8.21 State of California, Health and Safety Code, Section 17921.3 (Approved by the Governor April 2, 1976).

8.22 "Residential Water Conservation: The Suburban Maryland Experience 1970-1975," Mr. Michael J. Grear, Washington Suburban Sanitary Commission (a paper presented at the Conference on Water Conservation and Sewage Flow Reduction with Water Saving Devices, Pennsylvania State University, July 1975).

8.23 "Water Conservation in California," Bulletin No. 198, State of California Department of Water Resources, May 1976.

8.24 "The Clivus Multrum in Massachusetts," information distributed by Clivus Multrum U.S.A., Inc., Cambridge, Massachusetts.

8.25 "Proceedings of the Conference on Water Conservation and Sewage Flow Reduction with Water Saving Devices, Pennsylvania State University," prepared by U. S. Dept. of Commerce, Office of Water Research and Technology, July 1975.

8.26 "A Study of the Proposed Requirement for Mandatory Water Metering: A Report to the California State Water Resources Control Board", Arthur D. Little, Inc., June 1974.

CONTENTS

CHAPTER 9

CRITERIA AND PROCEDURES

Section	Title	Page
A	BASELINE DATA	9.2
	1. Wasteload Prediction	9.2
	2. Source Control	9.6
	3. Effect of Lack of Data	9.8
B.	FACILITIES PLANNING	9.11
	1. Chronology of Regulations	9.11
	2. The Present Facilities Planning Process	9.15
	3. Delegation to States	9.18
C.	ADMINISTRATION OF PUBLIC LAW 92-500	9.20
	1. Clearinghouse Process	9.20
	2. Priority Lists	9.21
	3. Construction Grants Program	9.21
	4. Areawide Waste Treatment Management	9.22
	5. Basin Planning	9.22
	6. Needs Survey	9.23
	7. Environmental Impact Statements	9.23
	8. Value Engineering	9.24
	9. The Permit Process	9.25
	10. User Charge Program	9.28
	11. Research Programs	9.29
D.	RESULTS OF GRANT PROGRAM THROUGH 1976	9.30
	1. Grants in Massachusetts	9.30
	2. Grants in Study Area	9.32
	3. Future Priorities	9.35
	4. Applications Pending	9.38
E.	INFLUENCE OF EPA	9.39
	1. Planning	9.39
	2. Research and Development	9.40
	3. Environmental Impact Statements	9.40
	4. NPDES Permit Program	9.40
	5. Clean Water Grant Program	9.43
F.	SUMMARY OF CHAPTER 9	9.45
	Table 9-1 Grant Funds for Massachusetts by Year	9.31
	Table 9-2 Study Area Grant Funds by Step	9.32
	Table 9-3 Grants to MDC and MDC Member Communities	9.33
	Table 9-4 Grants to Peripheral Area Communities	9.34

CHAPTER 9

CRITERIA AND PROCEDURES

This chapter reviews the data available on sources of raw wastewater discharging into the MDC system and discusses the effect of the lack of data regarding waste sources.

This chapter also reviews the administration of the clean water grant program and the facilities planning process. The status of grants awarded to agencies in the study area and the priority list are also reported.

A. BASELINE DATA

Wastewater flow entering the plant is presently measured at the Deer Island headworks, at the Deer Island Main Pump Station, at the Winthrop Terminal Pump Station, and at the Nut Island headworks. No measurement is made of flows bypassing the plants. Flow measurements indicate a unit annual average flow for the population served as 258 gpcd at Deer Island and 189 gpcd at Nut Island during FY 75-76. While it is recognized that these measurements included industrial contributions, they were affected by extraneous flows representing infiltration, wet-weather inflow and tidewater inflow. In addition, the measurements were affected by the fact that not all wastewater reached the meters due to upstream overflows and diversions and to bypasses around the meters. Furthermore, bypasses and overflows downstream from the meters can cause the measured flows to be different from the treated flows.

We have found no records of flows having been measured at the source or at the points where sewers of member communities are connected to the MDC System.

1. WASTELOAD PREDICTION

Inadequate data exist on the wastewater flows produced tributary to the MDC system. Some studies have been carried out on small tributary areas which were the basis of calculations to determine residential and commercial per capita flow contributions. These calculations appear reasonable. Industrial contributions, inflow and and infiltration have only been grossly estimated, largely based upon flows accepted by the Deer Island treatment plant. Since significant portions of the wastewater flows are bypassed or overflow directly to the Charles River or the harbor unmeasured, even in dry weather, the estimates are probably greatly in error. Due to the combined sewers, wet weather flow estimates are subject to even greater error.

Data on wastewater strength and composition are also questionable. Little is known about quality of wastewater by-passed or overflowed, either in dry weather or during storm runoff. Even the sampling of wastewater received at the treatment plants is of questionable validity because samples have been time-composited rather than flow-composited. Because of the method of compositing and the lack of analyses of discrete samples, mass loadings and mass emissions can not be accurately calculated.

Without accurate flow and wastewater quality data, treatment capacity can not be properly planned nor can cost-effective facilities to control overflows and by-passes be developed. This lack of data also does not permit evaluation of the extent of the problems imposed by salt water and river water inflows through defective tide gates and overflow structures. The indicated volume of this inflow will have severe economic impact on sizing secondary treatment facilities and can not be now evaluated. It can also have severe effect on the efficiency of treatment facilities.

The EMMA study used a flow quantification procedure to determine the recommended size of facilities. The procedure involved inputs of future water consumption, population, sewered areas, industrial activity, employment, and age of existing sewers. These inputs, together with the application of assumed unit values, resulted in the generation of criteria used to develop the size of recommended treatment plants for the future.

The EMMA Recommended Plan for Deer Island is based on assumed criteria to serve 1,425,000 person projected in the present member communities in the year 2000 as follows:

Component	Avg. daily flow, mgd	Equivalent gpcd
Residential/Commercial	177.3	124.2
Major Industrial	32.8	23.0
Other Industrial	15.2	10.7
Infiltration	128.5	90.2
Inflow	41.3	30.0
Subtotal	395.1	276.9

An additional average daily flow of 4.9 mgd predicted from three unsewered communities comprise the 400 mgd recommended capacity for Deer Island.

The average of the per capita flows in the Deer Island service area shown in the EMMA Report are less than those presently estimated for all components except "other" industrial. The present value for residential and commercial flow is reported as 92 gpcd.

The increase of 32 gpcd does not reflect any water conservation policy.

By comparison the interim output of the MAPC 208 program quantified flows for each basin in the 208 study area. They predicted total wasteloads for the year 1995 based on "high" and "low" flow criteria. Unit criteria for the residential component were computed based on 70 and 120 gallons per capita per day.

The average annual strength of the raw wastewater in FY 75-76 is shown in the MDC Annual Report. On a unit average annual basis, including industrial contributions, the loadings are as follows:

	Pounds per Capita per day	
	Deer Island	Nut Island
BOD	0.28	0.23
Suspended Solids	0.28	0.33

For the year 2000, the EMMA Recommended Plan provides for less industrial contribution but a greatly increased unit loading of BOD and Suspended solids. The future allowance shown is equivalent to the following:

	Pounds per Capita per day	
	Deer Island	Nut Island
BOD	0.38	0.31
Suspended Solids	0.35	0.37

The increase in per capita waste loads represent mass pollutants to be treated irrespective of the volume of wastewater or extraneous water.

Disinfection of treated effluent can be accomplished by a number of processes. Among the methods available for disinfection are the use of chlorine, ozone, ultraviolet light, iodine, and bromine. Salts of heavy metals, heat, extended storage time, and ionizing irradiation may also be used. Chlorination has been the most reliable and widely used method in this country. It is also a method that may leave a toxic residual which can have a detrimental effect on the receiving water. The efficacy of chlorination of raw sewage containing solids, high BOD and grease is unproven. The practice in Massachusetts of mandating chlorination of raw sewage without effective pretreatment to remove substance which interfere with disinfection, and requiring adequate contact time, has not proven effective. In addition, no concern has been expressed as to toxicity of discharge of chlorine or chlorine additions compounds.

2. STATUS OF SOURCE CONTROL

The MDC Sewerage Divsion has been operating under "Rules and Regulations Covering Discharge of Sewage, Drainage, Substances, or Wastes", established under Section 12 of Chapter 705 of the State Acts of 1975. They are required to be amended to conform to EPA requirements for a sewer use ordinance in accordance with 40CFR 35.920-3(b)(2).

a. NPDES Requirements

The NPDES permit issued to MDC August 12, 1976 requires, in accordance with the "Implementation Schedule" contained therein, to have in full force and effect throughout its sewerage system by September 1, 1976:

> (1) Rules and Regulations, specifying the terms and conditions under which connections for discharge of sewage, drainage, substances or wastes into any sewer under its control or any sewer tribuatary there, to be made, maintained, modified or used, and
>
> (2) an acceptable program for implementing and enforcing these rules and regulations against any source, public or private by MDC, its member communities, or any combination thereof.
>
> The permit gives minimum requirements for said sewer use ordinance regarding prohibitions of toxic, hazardous, and incompatible pollutants, pretreatment requirements, new or changed discharges into the system. The permit also requires that the ordinance have provisions regarding records, and,

monitoring of industrial discharges and authority to enter industrial premises, for access to records, inspection, and sampling.

(3) A survey of contributing industries is required to be complete July 1, 1978, whith progress reports made each January and July.

(4) The MDC is also required to establish an industrial waste section, fully staffed and equipped, by July 1, 1977 to implement the sewer use regulations, and industrial pretreatment programs.

b. Permit Compliance

In September 1976, MDC issued "Proposed Amended Rules and Regulations Covering Discharge of Sewage, Drainage, Substances or Wastes To Sewerage Works within the Metropolitan Sewerage District", publication no. 9206-26-300-976-CR. A Notice of Public Hearing was also issued. The notice advised that a public hearing would be held November 16, 1976, on the matter of revising the Rules and Regulations.

We understand that, as of the end of 1976, the required ordinance had not been adopted. We were advised by EPA that MDC was in violation of permit conditions by not having the ordinance in effect and in not having submitted the required progress reports.

We were advised by MDC that new rules and regulations can not be adopted until EPA issues standards for industrial pretreatment.

No source control or industrial cost recovery program was in effect by the MDC before the Step 3 grant was awarded for the Charles River Estuary combined sewer overflow station. There was no grant condition requiring source control or industrial cost recovery prior to approval of that project.

While a survey was made of industries in the MDC area, there is no record of any monitoring of wastewater quality produced by the industries or their flows. There was, however, a study which applied industry averages to the industries surveyed to develop an estimated industrial flow quantification. This estimate was not confirmed by measurements and may not be applicable to industries in the Boston area. The explanation was that many of the industrial installations are old and have multiple discharge points making monitoring difficult Because of the age of these installations, it is probable that wastewater quality and quantity may differ greatly from national industry averages. In particular, it is likely that toxic material discharges are higher than for industries that are being monitored elsewhere.

There is some information on toxic materials in treatment plant effluents and even less data on toxics in overflows and bypasses. Clearly, implementation of a sewer use ordinance is needed. This is needed as a basis of determining industrial cost recovery as required by regulations.

3. EFFECT OF LACK OF DATA

Adequate data are not available to determine the quantity and quality of wastewater flows, flow and strength variations and their causes, toxicity and treatability of wastewaters, collection and transmission facility deficiencies, bases for cost recovery and pretreatment requirements and design criteria.*

---

* (EPA advises that in 1978 the MDC embarked on a 2-1/2 year study involving industrial wastes, permits, pretreatment, user charges, and cost recovery.)

These deficiencies are summarized in a memorandum from Jerome Horowitz, Vertex Corporation, dated 21 Sept 1976 to NSF which is quoted in part as follows:

> "The first priority for wastewater surveys must be to characterize raw wastewaters accurately. Flows and loadings from all industrial and municipal connections to the MDC must be investigated in detail to determine (1) worst conditions, (2) average conditions, and (3) requirements for pretreatment and cost recovery. All three items of work must be accomplished before the planners and engineers can begin meaningful work on waste-treatment facilities. No engineer can design an STP rationally until he knows the amount, strength, and variation of the wastewaters to be treated.
>
> The second priority for wastewater surveys must be to characterize treated wastewaters accurately. Initially, attention should be focussed on NPDES permit holders, especially those holders who are responsible for unusually large, strong, or toxic discharges. The effluent monitoring specified in the NPDES permits is generally deficient; more types of analysis and more frequent analyses will almost always be necessary, and there must without exception be much more attention to accurate sampling and to quality control in the laboratory. Sludge discharges from the MDC must be investigated with special care, taking care to characterize them accurately under several conditions: (1) before extensive sewer repair, (2) after extensive sewer repair, (3) before instituting a full program of industrial pretreatment, and (4) after industrial pretreatment has been instituted.
>
> The investigation of industrial wastewaters must identify flows and loads from the several thousand industrial extablishments that are connected to the MDC sewers or its feeders. This information on industrial wastewaters is essential to compliance with sections 307 (a)-(d) and 311 (a) of P.L. 92-500 (i.e. pretreatment). Both industrial and municipal wastewaters must be carefully characterized for both wasteflow and wasteloads to comply with section 204 (b) of P.L. 92-500 (i.e. cost recovery); the cost-recovery provisions require wastewater monitoring over a broad range of conditions, not just during peak loads and flows, though accurate monitoring is most important then."

Analyses should also be made to determine the sources and amounts of inflows, the proportion of these that can be eliminated and the cost of this inflow elimination. The actual capacity of existing trunk sewers should be determined and the loss of capacity from the reported considerable sediment accumulation due to inadequate maintenance and from sewer deterioration determined. This will enable corrective action to be taken to restore capacity and eliminate significant overflows. This will permit realistic appraisal of relief sewer needs.

Data also need to be collected on the amount of sewage discharged at overflows and at by-passes, both during dry weather and wet weather. The causes of these discharges should be determined so that corrective action can be taken.

The lack of data tend to indicate the need for larger facilities than may be considered grant eligible. This may result in planning facilities that are not cost-effective solutions to the water quality problems. The courts have affirmed that EPA has the right to deny funds for projects that are not cost-effective.

The treatability in the proposed secondary treatment processes has not been demonstrated for the MSD wastewaters (particularly for Deer Island) with the significant variable sea water component. A survey of experience with plants in the United States and a literature search on salt water effects on secondary treatment, conducted in 1973 by Kennedy Engineers under contract with the U.S. Navy, disclosed certain limitations in secondary treatment facility design. Unless the salt water component is eliminated or significantly reduced, data should be developed from pilot plant studies to confirm treatability of the wastewaters by the process selected.

B. FACILITIES PLANNING

This section summarizes the evolution of the facilities planning portion of the Clean Water Grant Program.

Under PL 660, only one grant was made for a project, ususally at about the time the start of construction. The grant covered a percentage of the costs of:

A feasibility study or preliminary report, if any,

Design, and

Construction

After the EPA was created in 1970, the facilities planning process changed nationwide as follows:

1. CHRONOLOGY OF REGULATIONS

Major regulations affecting the facilities planning process are listed below:

o	October 18, 1972	PL 92-500 is enacted by the Congress.
o	August 17, 1973	Secondary Treatment is defined (Ref: 40 CFR 133) Since revised.
o	August 21, 1973	Rules and Regulations for User Charges and Industrial Cost Recovery are issued (Ref: 40 CFR 35).
o	August 23, 1973	Rules and Regulations for Public Participation are issued (Ref: 40 CFR 105). Since revised.
o	October, 1973	Guidelines on Pretreatment of Pollutants Introduced into Publicly Owned Treatment Works are issued.
o	November 8, 1973	Pre-treatment Standards published. (Ref. 40 CFR 128).

o	February 11, 1974	Final Rules and Regulations for Construction Grants for Waste Treatment Facilities are issued. Established the three separate steps for planning, design and construction. (Ref: 40 CFR 35) Since revised.
o	February 19, 1974	Procedures for compliance with requirements to Protect Properties on the National Register of Historic Places, is issued.
o	March 1974	An application kit for grants, containing forms, regulations and guidance is made available to prospective grantees.
o	March 1974	Guidance for Sewer System Evaluation issued.
o	March 1974	The 1970 FWQA Guidelines on Design, Operation and Maintenance of Waste Water Treatment Facilities are Supplemented by the first of a series of publications.
o	March 19, 1974	Rules and Regulations for Implementation of Uniform Relocation Assistance and Real Property Acquisitions Policies are issued. (Ref: 40 CFR 4)
o	May 13, 1974	Regulations for Areawide Planning (pursuant to Section 208) are issued. (Ref: 40 CFR 35)
o	June 3, 1974	Policies and Procedures for the State Continuing Planning Process and Basin Planning (pursuant to Section 303e) are issued. (Ref: 40 CFR 130, 131)
o	September 5, 1974	Procedures for Projects Impacting Wetlands are issued.

o	March 26, 1975	Proposed Criteria of the National Flood Insurance Program are issued. (Ref: 24 CFR 1909-17).
o	March 1975	Guidance on Evaluation of Land Application Systems is issued.
o	April 14, 1975	Final Rules and Regulations on Preparation of Environmental Impact Statements are issued, since revised. (Ref: 40 CFR 6)
o	April 16, 1975	Rules and Regulations for Administration of the Clear Air Act and the Federal Water Pollution Control Act with respect to Federal Contracts, Grants or Loans are issued. (Ref: 40 CFR 15)
o	May 1975	Guidance in Preparing a Model Facilities Plan is issued.
o	May 8, 1975	Grant Regulations and Procedures are issued. (Ref: 40 CFR 30) Since revised.
o	June 1975	A Guide to the Selection of Cost Effective Wastewater Treatment Systems is issue.
o	September 1975	Model Facility Plan for a Small Community is issued.
o	October 1975	Alternative Waste Management Techniques for Best Practicable Waste Treatment is issued. Since supplemented.
o	December 1975	Handbook for Sewer Sytem Evaluation Rehabilitation is issued.
o	December 1975	EPA Binder is issued to provide references and guidance, since revised.
o	February 1976	EPA Handbook of Procedures is issued. Provides checklist of procedures to be followed through each step of the grant program. Revised August and December 1976.

February 1976	Industrial Cost Recovery System Information issued, replaced November 1976.
March 1976	Model Plan of Study is issued to supplement Guidance for Preparing a Facility Plan.
March 1976	Task Force Report on Disinfection of Wastewater is released.
April 1976	Municipal Sludge Management, An Overview, is released.
July 1976	Value Engineering Workbook is issued.
July 26, 1976	Coliform limitation dropped from definition of Secondary treatment.
September 1976	Handbook of Construction Inspection Guidance is issued in 3 volumes, since revised.
October 26, 1976	Value Engineering, became mandatory on certain major projects for which Step 2 applications are certified to EPA after this date.
November 15, 1976	Application of Sewage Sludge to Cropland is issued.

The Binder of References instituted a series of Program Guidance Memoranda (PG), replacing Administrator's Decision Statements which were utilized in the early years of the program to disseminate policy from Washington. These have since been superseded by Program Requirements Memoranda (PRM). Through the EPA's Technology Transfer program, seminars are held throughout the country and binders of information on technical matters are also made available.

The EPA began issuing Process Design Manuals on Selected Technical Subjects as early as October 1971.

By the end of 1976, criteria to determine acceptability of discharges from ocean outfalls, as required by Section 403 of PL 92-500, had not yet been issued.

There seems to be an absence of guidance in the area of operation and maintenance, operator training, and start-up of facilities after construction.

2. THE PRESENT FACILITIES PLANNING PROCESS

The EPA Handbook of Procedures is probably the single publication that is most helpful to grantees and to prospective grantees. The Schematic Flow Diagram of the Construction Grants Process contained therein has been widely reprinted.

The Handbook lists the sequential requirements of the program as follows:

a. Pre-Step 1.

  (1) State Responsibilities, including mapping, informing prospective applicants and Priority System.

  (2) Preapplication Conference (optional).

  (3) Step 1 Application, including Plan of Study, Sub-agreements, and Clearing house Comments,

  (4) Review, for compliance with basin planning, priority, 208 planning, available funding, and prior costs.

  (5) Step 1 Grant offer,

  (6) Acceptance of Step 1 Grant,

b. Facilities Planning

  (1) Description of treatment works,

  (2) Description of System,

(3) I/I Analysis,

(4) Cost-effectiveness analysis,

(5) Discharge limits,

(6) Clearinghouse comments

(7) Public Hearing Summary,

(8) Legal/Financial Authority,

(9) Civil rights requirements.

c. State Review

(1) Compliance with requirements,

(2) Conformance with Basin Plan,

(3) Comment by 208 Planning entity,

(4) Conformance with existing 208 plan, if any.

d. EPA Review

(1) Cost effectiveness

(2) Acceptable effluent

(3) I/I requirements,

(4) BPWTT requirements

(5) Compliance with NEPA,

(6) Compliance with other environmental laws.

At this point, a negative declaration is made, or a notice of intent is issued and an EIS is prepared for the project recommended. In addition, a sewer system evaluation survey is performed if I/I is found to be excessive. The project is also verified with the state priority list before the step 2 application is made.

e. Step 2 Application

(1) Facilities Plan is submitted and approved,

(2) Assurance of compliance with user charges and industrial cost recovery,

(3) Statement regarding availability of site.

(4) Assurance of compliance regarding relocation assistance,

(5) Subagreements,

(6) Clearinghouse comments,

(7) General requirements regarding eligibility, non-federal costs, applicant capability to insure completion, and instutional arrangements,

(8) State/EPA review for compliance with application requirements, State and EPA approval of application,

(9) Step 2 grant offer,

(10) Acceptance of Step 2 Grant.

f. Step 2 Design Phase

(1) Preparation of Construction Plans and Specifications suitable for bidding,

(2) Inclusion of environment mitigating measures,

(3) Value Engineering,

(4) State/EPA review of design for compliance with design requirements for reliability, etc., and with procurement regulations, acts and other laws,

(5) Project approval and verified on the priority list.

g. Step 3 Application

(1) All requirements of Step 2 applications must be complied with plus the plans, specs and O & M compliance schedule and sewer use ordinance submittal and approval,

(2) State/EPA review for compliance with application requirements including O & M program.

(3) Step 3 grant offer,

(4) Step 3 grant acceptance.

h. Step 3 Construction

(1) Advertise for bids,

(2) Receive and open bids,

(3) State/EPA review bids, approve and authorize award,

(4) Award contract for construction,

(5) Hold preconstruction conference,

(6) Construction proceeds,

(7) Contruction Monitoring program,

(8) Operation and Maintenance Manual,

(9) User charge/industrial cost recovery systems,

(10) Sewer use ordinance,

(11) Property records program,

(12) Sewer evaluation and rehabilitation program.

(13) State/EPA review and approval,

(14) Final inspection.

i. Post Construction

(1) Prepare record drawings,

(2) Startup services,

(3) Operate and Maintain,

(4) Monitor performance.

3. DELEGATION TO THE STATES

There are a total of fifty-six states and territories to which the Clean Water Grant Program is available. EPA has the authority to delegate the administration portions of the program to States willing and capable of administering it. According to a recent report published in the Journal of the Water Pollution Control Federation, EPA had formally delegated to thirty-eight of the states and terrtories the administration of one or more parts of the program. EPA may not delegate its responsibilities under NEPA or for grant fund audit. The extent of formal delegation agreements is summarized below:

Major item delegated	No. of States
Plans and Specifications	37
O & M Manual	38
Change Orders	36
Permit Program	28

Thus, there are eighteen states and territories where the program is administered entirely by the EPA regional office, although the EPA may informally delegate certain functions to the states.

The Regional Administrator advises that Region I has not entered into any formal delegation agreements with the Commonwealth of Massachusetts, although some are planned in the future. At present NPDES permits are issued jointly, and some functions such as Step 2 review of plans are done by the DWPC under informal delegation agreement.

C. ADMINISTRATION OF PUBLIC LAW 92-500

This section presents an overview of the administration in the study area of portions of Public Law 92-500 related to facilities planning and the clean water grant program.

1. CLEARINGHOUSE PROCESS

The Metropolitan Area Planning Council (MAPC) serves as the Areawide Clearinghouse for 101-member communities in the Boston metropolitan area, including most of the communities within the EMMA study area. MAPC is the designated A-95 process clearinghouse in the Greater Boston area, and MAPC coordinates the OMB Circular A-95 review and comment process for "Notices of Intent" to file for Federal funding, including wastewater treatment construction grants.

The Metropolitan Area Planning Council provided Kennedy Engineers a listing of all Federal wastewater treatment grant applications that had been reviewed by MAPC as of 1 June 1976. MAPC's computer listings showed both pre-applications and full applications, and give the estimated total project cost.

Our review of the data shows very little correlation between the applications in the clearinghouse list and the grants processed or being processed in the EPA. Some discrepancies are obviously due to computer error. The output of the clearinghouse does not allow determination to be made of whether or not any of the applications have already been funded. The material available is believed to be of little or no value in estimating the needs for wastewater facilities.

2. PRIORITY LISTS

A draft and a revised priority list were made for fiscal year 1977 by the Commonwealth of Massachusetss DWPC in the fall of 1976. The FY-77 list is in two parts, the basic (or active) list for projects within the funds available, and an extended list of projects in a lower priority category for which funds are not expected to be available.

The Priority Lists are required by Section 106 of PL 92-500.

Before this year, all projects eligible for section 201 assistance were awarded grants on a first-come first-served basis as there were more funds available than were requested.

Details on the current priority list are included in the next section of this chapter.

3. CONSTRUCTION GRANTS PROGRAM

Within the State of Massachusetts, the Federal Clean Water Grant Program under Section 201 of PL 92-500 is administered by the Water Programs Division of EPA Region I. EPA has not formally delegated this authority to the State of Massachusetts. However, the Massachusetts 1973 Clean Water Act authorizes State grant funding of fifteen percent of the eligible cost of a wastewater project that receives a Federal Clean Water Grant (75 percent of eligible cost). The Massachusetts Division of Water Pollution Control (DWPC) reviews wastewater project grant applications and certifies the projects before the applications are forwarded to EPA Region I for review and, if approved, reviews the grant agreement. DWPC also reviews and approves final plans and specifications before Step 3, construction, can be initiated. In at least one case, a Clean Water project was entirely funded by the State. It appears, also, that some potentially grant eligible projects have been locally funded.

DWPC instituted during 1976 a computerized system of tracking each project from the pre-application stage through project completion. Sixty items of activities are updated for each project every two weeks. The EPA reviews state certified applications for conformance with planning and regulatory requirements. The areawide planning agency is also given the opportunity to review and comment on prospective projects.

Details of construction grants awarded are given in the next section of this chapter.

4. AREAWIDE WASTE TREATMENT MANAGEMENT

Areawide waste treatment management planning, pursuant to section 208, is being performed by the MAPC Water Quality Project office. The target date for completion of the 208 Plan is 1978.

While 201 facilities planning generally considers facilities to deal only with point-source municipal pollution of the type eligible for grant assistance, 208 planning also considers facilities to deal with diffuse or non-point sources as well as non-municipal sources of pollution which are not grant eligible.

5. BASIN PLANNING

Water Quality Management Plans, also known as Basin Plans, are being prepared by DWPC as required by Section 209 of PL 92-500. Plans have been published for two of the study area basins including the upper part of the Charles River.

As a part of the state's continuing planning process, as required by Section 303 (e), the river basins and coastal zones of the state were reclassified in May 1976. It is interesting to note that a century ago the world's first water purity records were produced in easter Massachusetts, and the first state water quality standards were established in the 1890's by the State Board of Health.

6. NEEDS SURVEY

Cost estimates for construction of publically-owned Wastewater treatment facilites were prepared in 1976 as reported in Chapter 3. It is noted that the results are low compared to the previous surveys and compared to other current surveys. The discrepancy can be accounted for by the failure to report in the 1976 Needs Survey the costs of the projects in the EMMA Recommended Plan or any other projects of the MSD. *

Of the $18 billion originally authorized by the Congress for grant assistance under the Federal Water Pollution Control Act Amendments of 1972, a total of $573.9 million (or 3.1883 percent) has been allocated to Massachusetts.

Massachusetts'share of future funds would be disproportionately small if they are allotted on the basis of estimated needs reported in the 1976 Needs Survey.

7. ENVIRONMENTAL IMPACT STATEMENTS

An Environmental Impact Statement or a negative declaration is required for each grant project pursuant to the National Enviromental Policy Act of 1969 (NEPA). Regulations show that the EPA is to

---

* (Costs were included in 1978 however.)

make an environmental review and a determination of negative declaration or intent to proceed with an EIS upon review of the completed Step 1 Facilities Plan and before the Step 2 grant application is made.

The Environmental Impact Statements are now being prepared in the study area for the Environmental and Economic Impact Office of EPA. The EIS on the MDC plan for primary sludge management was started after the Step 2 design work had begun. The EIS on a limited portion of the projects in the EMMA Recommended Plan is being performed before the Step 1 Facilities Plan has started.

We were advised by EPA on November 1, 1976 that the limited EIS will not address the subjects of the expanded service area, communities to be served, growth allowed, amount of wastewater to be treated, sizing and design criteria of facilities, reclamation and reuse, or water conservation measures and effect on facilities design. It appears that an EIS should be prepared to cover the entire program of 52 projects (plus local projects not included by EMMA) to determine if the program is the most cost-effective solution, as well as a study of each project to determine if each project is the most cost-effective.*

8. VALUE ENGINEERING

For all major projects for which the State certifies a Step 2 grant application on or after October 26, 1976, Value Engineering is mandatory. It is required for all projects having an estimated construction cost of $10 million or more; however, collector sewers and interceptors are exempt from the mandatory requirement. according to regulations published September 23, 1976. The purpose of Value

---

* (EPA feels this would be totally unworkable.)

Engineering is to extend cost-effectiveness efforts to focus on function and value in order to control cost and thereby assure quality and value design. Voluntary Value Engineering has been encouraged in the interim period since December 1974. Guidelines indicate the cost of Value Engineering is approximately one-half of one percent of construction cost; 75 percent of which is grant eligible. Since the effective date, the cost of Value Engineering can be included in the Step 2 grant funding.

The treatment works projects in the MDC program can be expected to be subjected to Value Engineering. In Region I of EPA, a Value Engineering office has been established. The Value Engineering Coordinator reviews each Step 2 grant application to determine if Value Engineering is required. No projects in Massachusetts have had Value Engineering performed as of July 1977, but it is proposed for the City of Lynn project.

9. THE PERMIT PROCESS

a. NPDES Permits

National Pollutant Discharge Elimination System (NPDES) permits are required for the discharge of pollutants, according to Section 402 of PL 92-500. In Massachusetts, permits are issued jointly by the Enforcement Division of EPA and by DWPC pursuant to authority granted in Chapter 21 of the Massachusetts General Laws. Each permit authorizes one or more discharges and contains:

(1) Effluent Limits,
(2) Implementation Schedule,
(3) Monitoring and reporting,
(4) Reporting and Non-compliance,

(5) A list of discharges, and

(6) General Conditions.

Permits are classified into five series according to the discharger: Municipal, Federal, Agricultural, and two forms of Industrial permits. The grant program applies only to municipal dischargers.

We are advised that permits have not been issued to all existing dischargers in the study area. For proposed new dischargers, permits are issued during the Step 3 construction period, a few months before the discharge is scheduled to commence.

Jointly with DWPC, EPA Region I issued to the MDC the first Enforcement Compliance Schedule Letter in the nation.

b. Compliance

Compliance with permit requirements is determined by the Enforcement Division of EPA, largely based on self-monitoring reports of the dischargers. The Surveillance and Analysis Division of EPA and the DWPC perform limited monitoring of discharges and also provide input regarding compliance.

A "NPDES Quarterly Non-Compliance Report" is issued quarterly. The report lists the number of municipal and industrial dischargers alleged to not be in compliance with one or more provisions of the permit.

There are 177 Massachusetts dischargers listed on the non-compliance report as of December 1976. There are forty-six listed, on one to twenty-two counts each, which are located in the study area. The breakdown is as follows:

Portion of Study Area	Municipal	Industrial	Total
MDC Service Area	9	10	19
Peripheral Area	18	9	27
TOTAL	27	19	46

c. Enforcement

Enforcement activities can be taken either by the EPA Region I Enforcement Divison or by the Commonwealth of Massachusetts Division of Water Pollution Control.

When non-compliance with permit conditions, effluent limitations, implementation schedules, and monitoring and reporting requirements are indicated, including lack of reports from dischargers, enforcement activities may begin. This usually starts with an informal letter. If results are not satisfactory, the following actions may be taken:

(1) A "308 letter" of inquiry from EPA is sent to the discharger,

(2) An adminstriative order is issued to cease and desist. This document informs of the facts of the case and directs that corrective action be taken by the discharger, and

(3) A "Referral" is made to the United States Attorney.

The Director of the Enforcement Division advises that enforcement is often handled informally when violations are beyond local control and deferments of scheduled events are often granted. However, when a local agency is on the priority list and grant funds are available but the community will not submit an application or vote the local share (10%) of funds, then formal enforcement actions are taken.

It has come our attention that some permit requirements may not be monitored. For example, there is apparently no monitoring of the requirement that the City of Boston obtain written permission from the MDC and the DWPC before new wastewater flows are connected the city sewers.

There is apparently no monitoring of the flow from the Moon Island outfall to determine that the untreated wastewater is discharged only on the ebb tide as required by the NPDES Permit.

10. USER CHARGE PROGRAM

Section 204 of Public Law 92-500 stipulates that the administrator of the Environmental Protection Agency shall not approve any grant for any publicly owned treatment works after March 1, 1973, unless he shall first have determined that the applicant

(1) has adopted or will adopt a system of chares to assure that each user will pay its proportionate share of the costs of operation and maintenance (including replacement) of any waste treatment services provided,

(2) has made provision for the payment to such applicant by the industrial users of that portion of the cost which is allocable to the treatment of such industrial wastes to the extent attributable to the Federal share of the cost, and

(3) has legal, institutional, managerial and financial capability to insure adequate construction, operation, and maintenance of treatment works throughout the applicant's jurisdiction.

We were advised that heretofore most local agencies have not has these provisions as a part of their operations. There are inadequate data on total flows and waste strength for both the individual member cities of MDC as well as industries within the cities which would permit development of rational user charges. Chapter 814 of the Commonwealth of Massachusetts Acts of 1975 took effect on July 1, 1976. This Chapter requires the MDC to modify certain of its administrative procedures and provides additional authority to carry out the requirements of Public Law 92-500.

11. RESEARCH PROGRAMS

Research, investigations, training and information programs are being carried out for the "prevention, reduction, and elimination of pollution" pursuant to Section 104 of Public Law 92-500. Research and development (R & D) grants are authorized in Section 105. The Office of Research Programs in EPA Region I has administered several demonstration and R & D grants in the study area, such as the ones previously documented for treatment of combined sewer overflows.

Public Law 92-500 also requires that research be conducted on several subjects including unnecessary water consumption and methods of reducing the total flow of sewage, and new methods of handling rural sewage.

A Report to Congress on reduction in water consumption and flow of sewage was made in February 1974 based on research done by the office of Air and Water Programs. Research in rural sewage disposal is being administered by the Municipal Environmental Research Laboratory of EPA in Cincinnati, Ohio.

D. RESULTS OF CLEAN WATER GRANT PROGRAM

The historical development of sewerage facilities in the Boston area from their beginning in colonial days progressing through the end of 1976 has been documented in Chapter 1. A general survey of existing wastewater facilities and plans for the future have also been presented.

This section shows the contributions for reducing pollution in the study area as a result of Public Law 92-500 to date. Particular emphasis is given to financial assistance for planning, design and construction of wastewater treatment facilities under Section 201 of the Act.

In Massachusetts, the Clean Water Grant Program is administered by EPA Region I in Boston. This authority has not been delegated to the Commonwealth of Massachusetts, as it has in many other states. The Massachusetts Clean Water Act of 1973, however, authorizes State grant funding of fifteen percent of the eligible cost of wastewater projects that receive Federal Clean Water Grants of 75 percent of the eligible costs. The Massachusetts Division of Water Pollution Control does review grant applications and certifies them to EPA Region I for further review and action on grant agreements.

1. GRANTS IN MASSACHUSETTS

Since the passage of the Federal Water Pollution Control Act Amendments of 1972, Massachusetts has been allotted $573,900,000 in Construction Grant Funds according to EPA Region monthly reports on the status of the Program. The status of funds obligated by fiscal year as well as the funds available as of December 31, 1976, are shown in Table 9-1. Forty-three percent of the allotment had not been obligated.

Table 9-1
GRANT FUNDS FOR MASSACHUSETTS BY YEAR

(in thousand dollars)

FY	Allotment	Obligated	Available	% obligated
73 and 74	$187,900	186,000	1,800	99
75	90,200	90,100	100	99
76 and 77	295,800	49,800	246,000	17
TOTALS	$573,900	326,000	247,900	

Note: The allotment for FY 76 represents the release of impounded funds and can be used through the end of FY 77 if obligated by September 30, 1977.

The length of fiscal years of the grant program under Public Law 92-500 has varied as noted below.

FY	Begin	End	Months
73	Oct. 1972	June 1973	9
74	July 1973	June 1974	12
75	July 1974	June 1975	12
76	July 1975	Sept 1976	15
77	Oct. 1976	Sept 1977	12

From the table it can be observed that the average obligation in the State for the thirty-three months from the beginning of the program through FY 1975 was $6.4 million per month. For the fifteen months of FY 1976, the average obligation was $1.5 million per month. It is also shown that the remaining allotment of funds require average obligations of $27.5 million per month for the nine months remaining (January through September) in order to use the balance of available funds by September 30, 1977. The impoundment of FY 76 funds affected the rate of obligation.

It is noted that Massachusetts ranked forty-sixth in the nation on percentage of available grant funds allotted.

2. GRANTS IN STUDY AREA

In the designated study area of Eastern Massachusetts $84.24 million of municipal construction grant funds had been obligated through December 31, 1976, according to the EPA Region I grants information and and control system construction status report of January 1977. *

We have examined the list of grants and categorized them by geographical location inside and outside the present MSD service area and by step. They are summarized in Table 9-2.

The amount of all municipal construction gratns made to study area communites was twenty-six percent of the grants made in the state.

A list of grants made to MSD and MSD member municipalities through December 31, 1976 is given in Table 9-3. Grants made to peripheral area communities are listed in Table 9-4.

Table 9-2

STUDY AREA GRANT FUNDS BY STEP
Total Amount Obligated by Grant Agreements for projects in the Study Area from 1972 through December 31, 1976.

	Inside MSD	Outside MSD (Peripheral Area)	Total Study Area
Step 1	$ 792,155	$ 327,713	$ 1,119,868
Step 2	631,749	1,289,554	1,921,303
Step 3	24,660,675	56,535,731	81,196,406
	$26,084,579	$ 58,152,998	$84,237,577

Of the thirty-nine grants made in the Study Area, twenty-four were in the peripheral area and fifteen were in the MDC area. Thirteen were Step 1 grants, nine were Step 2 grants, and seventeen were Step 3 grants for construction.

---

* (EPA advises the total allotment was obligated August 18, 1977.)

Table 9-3
Grants to MDC and MDC Member Communities
(Period 1973-1976)

GRANT NUMBER	GRANTEE	STEP	AWARD DATE	GRANT AMOUNT (Dollars)
0350	Cambridge, City of	3	76-08-16	575,838
0351	Cambridge, City of	3	76-10-08	3,112,778
0275	Holbrook, Town of	3	74-10-29	1,905,000
0503	Melrose, City of	2	76-08-16	109,875
0313	MDC - Primary sludge	1	76-07-08	135,750
0312	MDC - Charles R. CSO	3	75-05-28	17,095,125
0536	MDC - Nut Isl. I/I	1	76-11-09	441,005
0409	Newton, City of	1	76-07-12	46,500
0416	Randolph, Town of	2	76-09-24	237,699
0401	Reading, Town of	3	76-12-06	1,237,684
0521	Revere, City of	1	76-04-23	69,000
0415	Walpole, Town of	1	76-09-02	41,400
0412	Watertown, Town of	1	76-05-17	58,500
0269	Wellesley, Town of	3	74-09-06	734,250
0413	Westwood, Town of	2	76-11-18	284,175
15	TOTAL			$26,084,579

Note: EPA advises that seven additional grants were made to MDC in 1977 and 1978.

The list of grants to MDC furnished by EPA (October 1978) was compared to the August 1976 NPDES/ECSL Schedule. Of the 22 grant project steps scheduled to begin by September 1978, five grants were reported made (from 2 to 17 months later than scheduled) and no grants were reported for 15 other scheduled steps. (two other non-scheduled grants were also reported).

Table 9-4
Grants to Peripheral Area Communities
(Period 1973-1976)

GRANT NUMBER	GRANTEE	STEP	AWARD DATE	GRANT AMOUNT (Dollars)
0426	Avon, Town of	1	76-02-12	12,600
0388	Billerica, Town of	3	76-06-18	6,045,104
0297	Charles River P.C.D.	3	76-05-28	18,843,652
0573	Franklin, Town of	2	76-12-29	150,600
0605	Gloucester, City of	1	76-12-20	75,563
0300	Hull, Town of	3	75-09-19	9,696,000
0338	Hudson, Town of	1	75-11-07	78,375
0256	Ipswich, Town of	3	74-02-01	3,312,000
0395	Ipswich, Town of	1	76-11-05	14,625
0384	Marlborough, City of	3	76-02-27	530,475
0470	Marshfield, Town of	2	76-11-23	363,375
0410	Medfield, Town of	2	76-08-26	171,683
0411	Medway, Town of	3	76-12-14	1,505,366
0523	Medway, Town of	2	76-12-17	158,268
0465	Millis, Town of	1	75-10-09	33,600
0277	Peabody, City of	3	74-09-11	2,740,845
0397	Peabody, City of	3	76-11-16	2,936,517
0471	Rockland, Town of	2	76-11-29	381,503
0255	Rockport, Town of	3	73-12-26	2,571,750
0394	Rockport, Town of	2	76-05-10	64,125
0399	Salem, City of	3	76-11-18	3,104,022
0499	Saugus, Town of	1	76-04-30	70,575
0288	South Essex S.D.	3	75-12-09	5,250,000
0522	Wrentham, Town of	1	76-05-14	42,375
24	TOTAL			$58,152,998

Fifteen of the thirty-nine grants awarded during FY 75 and FY 76, were not on the priority lists.* An additional five grants were made during the year following that for which they were listed.

It is noted that the EPA has exercised flexibility in administering the program to award grants to agencies having approvable projects even though they are not on the current published priority list.

As can be observed from Table 9-1, $247.9 million is available for federal assistance in the Clean Water Construction Grant Program for the entire State. The amount that may be allotted to Eastern Massachusetts can be determined by examining the FY 1977 Priority List.

3. FUTURE PRIORITIES

The basic (active) Priority list dated December 7, 1976, shows $64,748,000 earmarked for projects in the study area as follows:

a. Metropolitan District Commision
The MDc would receive $4,810,000 for three MSD projects:

(1) Reading Intercepter, Step 3, $2,250,000,
(2) Fore River Siphon, Step 3, $1,950,000 and
(3) North I/I Study, Step 1, $610,000.

b. MSD Member Communities
Five cities and towns in the MSD Service area would receive $27,564,000 for twelve projects as follows:

(1) Boston, six Step 3 projects, $19,870,000
(2) Cambridge, two step 3 projects for sewer separation, $1,829,000.
(3) Malden, a step 2 and a step 3 project $1,032,000.
(4) Melrose, one step 3 project, $1,000,000, and
(5) Wakefield, one step 3 project, $984,000.

c. Peripheral Area
Cities, Towns and Districts outside the MDC Study area would receive $33,060,075 for thirteen projects:

(1) Duxbury, Step 1, $15,075.

---

* (See Note on page 9.38.)

(2) Lynn, Step 2, $1,200,000 for a plant.
(3) Medfield, Step 2, $3,000,000 for interceptors and collector sewers.
(4) Milford, Step 2, $500,000 for an advanced waste treatment plant.
(5) Nahant, Step 2, $120,000 for interceptor, pump station and force main to Lynn.
(6) Rockland, Step 3, $3,800,000 for interceptors and an advanced waste treatment plant.
(7) Rockport, Step 3, $2,920,000 for collector sewers, pumps station and force main.
(8) Scituate, Step 2, $150,000 for collectors, pump station, interceptors, and plant additions.
(9) SESD, Salem, Step 3, $13,500,000 for Danvers-Beverly interceptor.
(10) Sudbury, step 3, $525,000 for treatment of septage.
(11) Tewksbury, Step 3, $6,780,000 for collectors, pump station and interceptor to Lowell (export out of study area).
(12) Westborough, Step 2, $400,000 for advanced waste treatment plant with Shrewsbury.
(13) Weston, Step 2, $150,000, for collectors, pump station and force main.

In addition to the basic active priority list, there is an extended priority list of 52 projects totaling $202,763,000 in the study area. More than half are in the peripheral area. On the extended list are three Step 3 MDC projects as follows:

Deer Island Sludge Incinerator	$17,250,000
Squantum Pump Station	$ 450,000
West Roxbury Interceptor	$ 4,050,000

The incinerator is designated Priority Item 1 in the EMMA Report; however, the final EIS has not been completed.

We have compared the adopted list with the preliminary list. The preliminary list did not contain the Duxbury and Weston projects and contained one less project for the City of Boston. The preliminary list showed five projects for MDC while the final list has only three.

It is observed that for the three MDC projects on the adopted list, the first two are not found on the list of required construction projects contained in the NPDES compliance schedule. The last MDC project on the adopted list corresponds to Priority Item 4 of the EMMA Recommended Plan.

Four other projects contained in the EMMA Recommended Plan which are scheduled for the start of Step 1 facilities planning during FY 77 are not on the adopted statewide priority list. These are:

EMMA Priority Item	Start	Description
3	January 1, 1977	Dorchester Bay CSO Project
12	January 1, 1977	Charles River CSO Project
13	January 1, 1977	Neponset River CSO Project
14	April 1, 1977	Framingham Extension Service

The starting dates shown are those given in the ECSL as the latest date that the MDC may initiate facilities planning and not be in violation of the NPDES permit. Because these projects do not appear on the priority list, it would appear that there will be no grant eligibility for these projects during FY 77. Furthermore, the escape clause in the ECSL appears to allow postponement of initiation of facilities planning until appropriations are made.

There are also projects shown on the EMMA Recommended Plan and contained in the NPDES permit which are due to start facilities planning to later than one day after the end of the FY 77. None of these projects are on the adopted priority list.

EMMA Priority Item	Start	Description
5	October 1, 1977	Expand Nut Island Primary Plant
6	October 1, 1977	Expand Deer Island Priamry Plant
7	October 1, 1977	Secondary Treatment for Nut Island
8	October 1, 1977	Secondary Treatment for Deer Island
9	October 1, 1977	Secondary Sludge Management
10	October 1, 1977	Middle Charles River area AWT*
11	October 1, 1977	Upper Neponset River area AWT*
* or 10A and 11A	October 1, 1977	Relief Interceptors and increased capacity at Nut Island

4. APPLICATIONS PENDING

At the end of 1977, applications of study area communities were being reviewed by EPA as follows:

Project no.	Applicant	Step	Grant Amount
0445	S.E.S.D.	1	$348,300
0386	Beverly	1	22,000
0418	Stoughton	2	126,375
0341	Boston	2	630,000
0579	Hull	2	121,300
0447	Northborough	2	250,015
0386	Ashland	2	56,250
0394	Rockport	2	"Grant increase"

Note: Projects funded which were not found on the priority list are for:

Avon
Franklin
Gloucester
Hull
Hudson
Ipswich
Medway
Millis
Saugus
Wrentham
MDC (2)
Revere
Walpole
Wellesley

E. INFLUENCE OF THE ENVIRONMENTAL PROTECTION AGENCY

The EPA, New England Region has influenced local water pollution control activities as follows:

1. PLANNING

a. The EPA has been actively involved in numerous joint pollution surveys, public hearing, preliminary planning reports, commissions and other pre-Step 1 planning for wastewater facilities in the Boston Harbor area. Regionalization to serve unsewered areas has been encouraged.

b. The Regional Administrator has not yet developed waste load allocations as required by PL 92-500.

c. EPA has accepted the EMMA Report as the "Basin Plan" even though the Report is incomplete since it does not include all facilities needed to provide adequate levels or water quality protection and does not include all information required for a Basin Plan.

d. No standards of performance have been established for combined sewer overflow treatment. Processes demonstrated to be ineffective have been mandated for this treatment. These overflows have been identified as the most important source of pollution in the area, creating a health hazard and affecting recreational use.

e. The EPA has been solely responsible for insisting on advancing the implementation schedule and planning for secondary treatment at Deer Island and Nut Island, as required by Federal Law.

f. Little or no consideration seems to have been given so far in the planning process to programs which would reduce the amount of wastewater from residential, commercial and industrial establishments connected to municipal sewers and, therefore, allow smaller size wastewater facilities.

2. RESEARCH AND DEVELOPMENT

The EPA has funded several demonstration projects in the Study Area. As of the end of 1976, the draft reports of performance of the demonstration projects had not been accepted for publication by the U.S. EPA Office of Research and Development.

3. ENVIRONMENTAL IMPACT STATEMENTS

a. The EPA has prepared a Draft Enviromental Impact Statement on the MDC Plan for Sludge Management for the existing Deer Island and Nut Island Plants. That project has been stalled pending preparation of the Final Environmental Impact Statement.

b. The EPA has initiated preparation of another Draft Environmental Impact Statement for some of the MDC Projects in the EMMA Recommended Plan. This EIS will cover expansion of the Deer Island and Nut Island Plants and the new Satellite Plants. It will not cover the question of secondary treatment (mandated by law) or the issue of how combined sewer overflows should be treated and where they should be discharged. It also does not include the question of peak capacity at Deer Island to reduce overflows and whether or not intermittent peak dry weather flows require secondary treatment.

4. NPDES PERMIT PROGRAM

a. An NPDES Permit was issued jointly by the Commonwealth of Massachusetts and EPA to the Metropolitan District Commission. It was accompanied by an Enforcement Compliance Schedule Letter (ECSL) which extends implementation dates to agree with the MDC Schedule. Other effects of the Permit were previously noted.

b. Through the NPDES Permit system and the accompanying ECSL the DWPC and the EPA have influenced the priorities and timing of project implementation. The most significant influence of EPA resulted in moving the construction date for secondary treatment facilities about fifteen years sooner on the schedule.

c. The NPDES Permit jointly issued by the EPA and the Commonwealth of Massachusetts DWPC to the Commonwealth of Massachusetts Metropolitan District Commission authorizes the discharges of primary and secondary effluents and combined sewage overflows in the amounts and general location as proposed in the EMMA Recommended Plan.

d. The EMMA Recommended Plan, accepted by the EPA, provides for construction of Satellite AWT plants on the upper Charles River and the upper Neponset River without specifying the effluent level to be provided for discharge to these rivers. It appears that the Neponset River plant (and possibly the Charles River Plant) may be prohibited under Water Quality Standards from discharging into these water quality limited river upstream of existing discharges. *

e. The EPA, jointly with the Massachusetts DWPC, has been instrumental, through the issuance of the NPDES Permit and Enforcement Compliance Schedule Letter to the Metropolitan District Commission, in establishing the hydraulic capacity and process to be used for combined sewer overflow projects to be designed and constructed in the future, but

* (The draft EIS of 1978 states that the concept of satellite treatment systems was eliminated in the early screening.)

has not established the level of treatment required. Projects are required to be of a size such that "untreated" discharges will not occur due to rainfalls of less than a storm of one-year severity and six-hour duration. While no "effluent limits" are established, the four major proposed projects are to attain operational levels to meet "effluent limits" specified in the permit by the dates shows below:

Dorchester Bay, By February 1, 1983,

Charles River, including the Muddy
River and Back Bay Fens, by February 1, 1983,

Neponset River, by February 1, 1983, and

Boston Inner Harbor, by January 1, 1986.

The scheduled completion dates for the first three projects are over two years sooner than the completion dates for secondary treatment of dry weather flows at Deer and Nut Islands.

f. The "best practicable control technology currently available" for treating combined sewage which is metioned in the NPDES Permit issued to the Metropolitan District Commission had not yet been defined as of the end of 1976.

The "attainable percentage removal level" for treatment works which receive flows from combined sewers has not been defined.

g. We observe that the NPDES requirements are deficient regarding combined sewage in three areas as follows:

> First, it is not stated how much, if any, of the combined watewater should be retained and reconveyed to the Deer Island Treatment Plant;
>
> Second, the "effluent limits" do not contain specific requirements or even guidelines for removals to be obtained in the treatment process, limiting standards to be met in the effluent, nor standards to be achieved in the receiving

waters. The degree of disinfection to be achieved or the upper limit of chlorine residual in the effluent also are not given; and

Third, the permit mandates, in a general way, the process and three specific unit operations which must be used.

Fourth, the permit does not give a specific location for the proposed discharges.

h. Many permits have been issued to Study Area communites authorizing discharges or untreated wastewater, primary effluent, overflows, and bypasses. Most were due to expire by June 30, 1977.

To summarize, it is clear that the Permit program is not used as the method of communicating the degree of treatment needed nor the acceptable location for proposed discharges.

No definitive requirements have been established for effluent quality from facilities to be provided to treat overflows. Data available indicate that present and planned overflow treatment facilities are ineffective in reducing BOD, suspended solids, floating matter, and bacterial contamination to acceptable levels.

The NPDES Permits jointly issued by the State and EPA are permissive of very low degrees of treatment, are silent on several important effluent limits, and continue to allow raw sewage and combined sewer overflows and bypasses.

5. CLEAN WATER GRANT PROGRAM

a. Most of Massachusetts' allocation of Clean Water Grant funds have been awarded to communities remote from Boston Harbor.

b. The EPA has made only one Step 3 construction grant to the Metropolitan District Commission. That grant will provide Federal assistance for a project to divert combined sewage overflows from the Charles River Basin Impoundment to the Charles River Estuary below the new dam being built by the Corps of Engineers.

c. It is readily apparent that not all present raw sewage discharges, overflows and bypasses in the Study Area will be corrected with assistance from the present Clean Water Grant Program before current funding allotments expire in September 1977.

d. There is no maximum size for grant eligible facilities applied to limit flows consistent with available water conservation and waste flow reduction measures. (EPA reports that no grant money has ever

e. From the beginning of the Clean Water Grant Program through Fiscal year 1976, there have been more funds available than eligible certified projects in Massachusetts. In Fiscal year 1977 the number and cost of otherwise eligible projects exceeds the remaining grant funds available. (EPA reports that no grant money has been reallocated).

f. The Areawide Waste Treatment Management Plan being conducted by the Metropolitan Area Planning Council (MAPC) pursuant to Section 208 of Public Law 92-500 will be completed after presently allotted grant funds available under Section 201 have been obligated.

g. The Regional Administrator has not entered into any formal agreements with the Commonwealth of Massachusetts to delegate responsibilities under PL 92-500.

h. EPA Headquarters began November 23, 1976 to issue a series of Construction Grants Program Requirements Memoranda to Regional Administrators to provide policy concerning implementation of the Clean Water Grant Program. These were not available during preparation of the EMMA Study.

F. SUMMARY OF CHAPTER 9

1. There appear to be no criteria applied in the study area to limit the size or planning period for ultimate capacity of grant eligible facilities, as of the date this report is written.

2. Inadequate data exist to permit rational planning and design of facilities. The lack of an adequate data base regarding sources of wastewater in the MDC Service area has caused the need to make assumptions, some of which appear so liberal as to result in over design of facilities.

3. Inadequate data are available to determine that the selected program is the most cost-effective solution to the area water quality control problems. Cost-effectiveness analyses have been limited to individual projects under the entire program, which in itself has not been determined to be the most cost-effective.

4. At the end of calendar year 1976, forty-three percent of available grant funds in Massachusetts had not been allocated. Awards have been made principally on a first-come-first-served basis. The amount of grant fund applications has been less than the funds available.

Most grant funds have been awarded for projects remote from Boston Harbor. Potentially eligible projects of MDC however, could soon exceed the remaining available funds.

5. The EPA has been solely instrumental in obtaining committments for high priority implementation of secondary treatment at the Boston Harbor plants, as required by Federal Law.

6. Up to the end of our Study Period, the Metropolitan District Commission had received only three grants under this program: the first grant was for the Charles River combined sewer overflow facility. It was a Step 3 grant for construction of a project that was planned before enactment of Public Law 92-500. The second grant was for primary sludge management and was also performed before grant program regulations were issued. It was a Step 1 grant and was made retroactively three years after the Report was finished.* The third grant was another Step 1 grant and was for infiltration/inflow analysis of the Nut Island interceptors. Work on this project had not begun during our study period.

*(EPA advises that this procedure is both allowable and common.)

CONTENTS

CHAPTER 10

ALTERNATIVES

Section	Title	Page
A.	PURPOSE OF CASE STUDY	10.4
	1. Historical Development	10.4
	2. Present Situation	10.5
B.	COST-EFFECTIVE ANALYSIS	10.7
	1. Federal Guidelines	10.7
	2. Present Worth	10.8
	3. EPA Proposed Regulations	10.11
C.	FEDERAL INTERAGENCY STUDY TEAM ALTERNATIVES (CATEGORY I)	10.15
	1. Alternative IA, Basic Upgrading	10.21
	2. Alternative IB, Expanded Treatment Facilities	10.28
	3. Alternative IC, Unlimited Growth	10.30
	4. Alternative ID, With Combined Sewage Flows	10.37
D.	EMMA RECOMMENDED PLAN (CATAGORY II)	10.42
	1. Alternative IIA	10.44
	2. Alternative IIB	10.49
	3. Staging the Secondary Treatment Facilities	10.52
E.	ALTERNATIVES TO THE EMMA RECOMMENDED PLAN (CATEGORY III)	10.54
	1. Alternative IIIA-Consolidation Option	10.58
	2. Alternative IIIB, Two Secondary Satellite Plants	10.63
	3. Alternative IIIC, Two Secondary Satellite Plants	10.68
	4. Alternative IIID, Two Land Satellite Plants	10.71
	5. Alternative IIIE, One Secondary Satellite Plant	10.73
	6. Alternative IIIF, One Secondary Satellite Plant	10.77
	7. Alternative IIIG, One Land Satellite Plant	10.79
	8. Alternative IIIH, One AWT Satellite Plant	10.81
	9. Alternative IIIJ, Ocean Disposal Option	10.84
	10. Alternative IIIK, Primary Treatment	10.88

CONTENTS (CONT)

Section	Title	Page
F.	COMPARISON OF ALTERNATIVES	10.90
G.	SUMMARY OF CHAPTER 10	10.100
	REFERENCES	10.103
	Figure 10-1 Plant Service Areas in Recommended Plan Year 2000	10.43
	Figure 10-2 Consolidation Option Alternative III A	10.59
	Figure 10-3 Kennedy Engineers Plan for Satellite Treatment Plants Alternative III B	10.64
	Figure 10-4 Ocean Disposal Option Alternative III J	10.85
	Figure 10-5 Summary of Alternatives	10.91
	Table 10-1 Flow Quantification and Loadings in the EMMA Study	10.47
	Table 10-2 Influent Loads and Populations Served	10.93
	Table 10-3 Character of Emissions	10.94
	Table 10-4 Quantities of Sludge Produced	10.95
	Table 10-5 Monetary Cost Summary	10.96
	Table 10-6 Project Costs, Alternatives I, II, & III (100% Grant Eligibility)	10.97
	Table 10-7 Assumed Grant Fundable Costs	10.98
	Table 10-8 Monetary Ranking of Alternatives	10.99

Chapter 10

ALTERNATIVES

It has been shown that many types of wastewater problems in the Boston Metropolitan area remain to be solved. For a century these problems have been the subject of investigations, studies, and public hearings as well as legislation and administrative rulemaking.

The solution of some of the wastewater problems in the expanded Metropolitan Sewerage District service area is proposed to be provided by implementing the recommendations of the intensive interagency EMMA Study, reference 10.1. However, many problems of a local nature are not included in the EMMA Recommended Plan and must be solved by the local agencies involved. Regional facilities planning must proceed and be implemented by the Metropolitan District Commission (the lead agency), in technical, financial and administrative cooperation with the State of Massachusetts and the Environmental Protection Agency. The EMMA Report identifies the next steps to be taken, options to the Recommended Plan, and major unanswered issues. Although the EMMA Recommended Plan has been adopted for project implementation, there are issues still to be resolved.

Major technical issues were concisely presented at the Water Pollution Control Federation 49th annual Conference October 1976 in Minneapolis by the principal authors of the EMMA Report, Martin Weiss, Director of Environmental Planning, MDC, and Jekabs P. Vittands, Vice-President, Metcalf & Eddy, Inc., reference 10.2. Their paper concludes as follows:

> "In summary, the EMMA report presents a number of outstanding wastewater treatment issues of Metropolitan Boston, some of which remain to be resolved. First, the issue of whether the requirement of secondary treatment of wastewater discharged to the ocean is both cost effective and environmentally beneficial. Second, the issue of sludge disposal. Third, the issue of when and how to expand and extend the Deer Island and Nut Island treatment plants for secondary treatment. The filling in of 30 acres of the Harbor is required for secondary facilities at Nut Island. At Deer Island, recreation and expansion of prison facilities are competing uses. Fourth, the importance of regulating the pollution from local combined sewer overflows. Fifth, the issue of whether, and where, to locate advanced treatment (satellite) plants along the Charles and Neponset Rivers. The communities adjacent to these rivers are members of MSD and are not enthusiastic about wastewater treatment plants in their neigborhoods. It appears that some form of compensation to the host commmunity will be required.
>
> Finally, it remains to be seen how and when these many vital issues will be resolved under the unending requirements of Federal regulations. When will construction actually begin and provide necessary facilities for cleaner waters in the Eastern Massachusetts Metropolitan Area?"

An Environmental Impact Statement is now being prepared on the issues of sludge treatment, the Deer Island and Nut Island plants, and the satellite plants. The Environmental Impact Statement scope of work does not cover the issues of secondary treatment or combined sewer overflows. It also does not cover major problems regarding excessive infiltration and inflow, the need for sewer separation and rehabilitation, and the amount of wastewater and size of treatment works.

This chapter is intended to summarize the assumed conditions for purposes of interdisciplinary evaluation of the Environmental Protection Agency's wastewater facilities planning process in the Boston Case Study. The time frames and alternative future plans are as follows:

PAST:

- Historical Development

PRESENT:

- Present Situation

FUTURE:

- Federal Interagency Study Team Alternatives (Category I)
- EMMA Recommended Plan (Category II)
- Alternatives to the EMMA Recommended Plan (Category III)

A. PURPOSE OF CASE STUDY

The purpose of the Boston Case Study is to document and evaluate the decision-making process in the administration of the Clean Water Grant Program in the Boston Metropolitan Area. The evaluation by the Federal Interagency Study Team and their consultants, in performing the Case Study, is intended to observe the actions involved in reaching decisions and not to influence those decisions. The Team is interested more in how a decision is reached than what the final decision actually is, reference 10.3.

One purpose of Kennedy Engineers' Report is to uniformly define the case study scenario for members of the Federal Interagency Team and their other consultants. The following situations are used as guidelines in further examination of the case in the Phase II Study. Comparisons of monetary costs of selected alternatives may be made on the basis of the present worth of capital costs and operation and maintenance costs which are developed in this Engineering Report.

Because of the enormity and complexity, as well as the interrelationships between the issues in this Case Study, we have kept the number of variables in any one alternative to a minimum. The Case Study alternatives are also limited to the 51 communities proposed to be included in the future expanded Metropolitan Sewerage District service area.

The various conditions for the Case Study follow:

1. HISTORICAL DEVELOPMENT

The historical development of wastewater facilities in the Boston Area was outlined in Chapter 1. Included were some of the key administrative, legislative and rulemaking actions which have taken place. The history of the Metropolitan Sewerage District is noted in relation to how the existing facilities developed.

2. PRESENT SITUATION

Of the 51 communities in the alternative analysis, it is noted that 42 are served in whole or in part by the Metropolitan Sewerage District at present and that nine are unsewered. 43 are members of the MSD.

The existing condition of facilities is based upon reported or observed conditions in 1976. Operating data are for the Metropolitan District Commission Fiscal Year of July 1975 to June 1976, the last year for which data were available. Data on the State and Federal Clean Water Grant Program include information to the end of calendar year 1976, which includes one-fourth of the Federal Fiscal Year 1977.

a. Deer and Nut Island Systems. The condition of facilities of the Metropolitan Sewerage District dry-weather flow sewerage systems is described in Chapter 2. Data for the northern service area, served by the Deer Island plant and data for the southern service area, served by the Nut Island plant, are presented separately. The data include service areas, populations, estimates of influent loadings, effluent emissions and general locations of dry-weather flow discharges used in this Case Study.

b. Raw Sewage Discharges. The raw sewage discharge problems of the Study Area and the general character of present discharges of untreated wastewaters are described in Chapter 4.

c. Combined Sewer Overflows. The existing situation with respect to combined storm water/sanitary sewage overflows is given in Chapter 5. The existing facilities for treatment of combined sewer overflows are also described in that Chapter.

d. Infiltration/Inflow. At present, a large amount of the flow being treated by the MDC is not sewage, but extraneous water as a result of infiltration/inflow. This flow is due in part to the age and poor condition of some of the sewers and to faulty tidegates, reverse flow over overflow weirs, and direct connections of stormwater conduits. This existing situation is important in developing the Federal Interagency Study Team Alternatives, and is discussed in Chapter 6.

e. Extent of Consolidation. The question of regional consolidation versus individual or community sewerage systems is discussed in Chapter 7. Comparative costs for unsewered areas are also given.

f. Conservation. Practices and opportunities for waste flow reduction are described in Chapter 8.

g. Criteria. Unit values for basic design criteria, grant program procedures, and the need for basic data are discussed in Chapter 9.

It should be noted that no facilities plan or environmental impact statement covering the proposal regional system improvements had been available during the course of this case study.

B. COST-EFFECTIVE ANALYSIS

EPA has promulgated regulations to aid in screening candidate plans and selecting viable alternatives. The purpose is to assure that the alternative selected is the most cost-effective. The analysis takes into consideration annual as well as capital costs, and short-term and long-term non-monetary impacts. The analysis is required as part of the Step 1 facilities planning process. It does not, however, consider the effect of inflation on staged construction or on operation costs. While this can not be quantified with any certainity, it could affect the desirability of alternative selection.

Final Construction Grant Regulation, 40 CFR Part 35, state:

> "Facilities planning will demonstrate the need for the proposed facilities and, by a systematic evaluation of feasible alternatives, will also demonstrate that the proposed measures represent the most cost effective means of meeting established effluent and water quality goals, recognizing enviromental and social consideration."

1. FEDERAL GUIDELINES

Current guidelines given in Appendix A of 40 CFR Part 35, which were issued pursuant to Section 212 of PL 92-500, define cost effective analysis as:

> "An analysis performed to determine which waste treatment management system or component part thereof will result in the minimum total resources costs over time to meet the Federal, State or Local Requirements."

The Guidelines set forth procedures and methods, portions of which are as follows:

> "All feasible alternative waste management systems shall be innitially identified. These alternatives should include systems discharging to receiving waters, systems sing land or subsurface techniques, and systems employing the reuse of wastewater."

> "The resources costs shall be evaluated through the use of opportunity costs. For those resources that can be expressed in monetary terms, the interest rate.....,(of 7 percent per year) will be used. Monetary costs shall be calculated in terms of present worth values.....over the planning period as defined .....(as 20 years)."
>
> "The most cost-effective alternative shall be the waste treatment system determined from the analysis to have the lowest present worth.....without overriding adverse nonmonetary costs and to realize at least identical minimum benefits..."

Included also are procedures showing that elements of monetary resource values are both capital costs and annual costs for operation and maintenance, and that interest during construction, service life, and salvage value will be reflected in the analysis. It is further required that components of cost shall be in the basis of market prices prevailing at the time of the analysis and inflation shall not be considered. Future costs of energy may have significent unquantified effect on project feasibility.

2. PRESENT WORTH

Kennedy Engineers has developed a standard model to compute present worth in accordance with EPA regulations. The present worth of the facilities in the EMMA recommended plan, which we report in Chapter 3, utilizes the standard procedure but are at the price levels used in the EMMA Report.

The procedure, as adapted for this study, determines the following:

a. Total Present Worth

Present worth of an alternative is the sum of capital cost present worth and operation and maintenance cost present worth of all the components of that alternative. Value of existing facilities reused is not included.

b. Capital Cost Present Worth

Capital Cost Present Worth of an alternative is the sum of the capital cost present worth of initial capital cost less the the present worth of salvage value for all components of the alternative. For each component, calculations involve the following:

(1) Standard Inputs, in accordance with EPA Regulations:
  (a) Interest at 7% (Presently 6 5/8%),
  (b) Study period of 20 years,
  (c) Facilities service life of 10 to 50 years. For this alternative study, we have simplified average service life of facilites as follows:
    (i) Pipelines, 50 years,
    (ii) Pumping stations and treatment plants 30 years, and
  (d) Inflation, zero.

(2) Assumptions for this study:
  (a) Base date of the analysis is assumed as January 1975, as in the EMMA Report,
  (b) Base date price level is assumed as ENR CCI 2200, as in the EMMA Report,
  (c) End of planning period, December 2000, to coincide with the completion of construction of the last priority item in the MDC staging schedule, and
  (d) Beginning of planning period, twenty years earlier or January 1981.

(3) Inputs Determined by alternative project:
  (a) Estimated Capital Cost of grant eligible facilities at base date price level, including construction, engineering, administration, legal costs, and contingencies. Normally, 75% of the capital cost is the Federal share. An allowance of 25-50 percent was made for non-construction costs, such as for planning and design,
  (b) Date of midpoint of construction, month and year, from construction schedule,
  (c) Construction period, in months from construction schedule,
  (d) Date of last use, corresponds to end of planning period, (year 2000), and

  (e) Age of facility at end of planning period.

(4) Calculated Values, as follows:
(a) Interest during facility construction, carried from one-half of the construction period at given interest rate.
(b) Present worth of capital cost plus interest during construction, at the base date, brought back from midpoint of construction.
(c) Salvage value, based on straight-line depreciated capital cost remaining at the end of planning period to reflect unused period of service life,
(d) Present worth of salvage value at base date, and
(e) Net present worth at base date which is present worth of capital cost and interest during construction less present worth of salvage value.

c. O & M Present Worth

O & M Present Worth of an alternative is the sum of the present worth of the O & M cost of all project components of the alternative. For each component, calculations involve the following:

(1) Standard Inputs and assumptions are the same as for construction cost.

(2) Inputs determined by the project used to determine O & M present worth are:

(a) Beginning date of operation, month and year, coinciding with date at end of construction period,
(b) Ending date of operation, month and year, coinciding to date at end of planning period,
(c) Estimated annual O & M cost over the period of operation, often assumed a uniform amount per year or the average of the variable annual costs for simplification.

(3) Calculated values, as follows:

(a) Uniform Series Present Worth Factor (USPWF) at given interest rate, for the period of operation of the facility,
(b) Present worth of annual O & M cost over the operating period brought back to date of beginning of operation, using USPWF,

(c) Single Payment Present Worth Factor (SPPWF) to adjust from date of beginning of operation to base date, and

(d) Present Worth of O & M at base date, using SPPwf.

3. EPA PROPOSED REGULATIONS

In February 1977, the EPA published proposed guidelines to amend and supplement the Cost-Effective Analysis Guidelines (40 CFR, Part 35, Subpart E-Appendix A), reference 10.4. The proposed amendment is to aid in the preparation of facility plans, and is:

> "intended to provide for cost-effective facility sizes and sufficient reserve capacity and, at the same time, to avoid overdesign."

The proposed regulations would provide guidance in the following areas critical to the sizing of treatment and collection systems:

Population projections,
Wastewater flow estimates,
Treatment plant staging, and
Interceptor staging.

These are abstracted below:

a. Population Projections

Each state is to "disaggregate" the State projections for populations and economic activity among its Standard Metropolitan Statistical Areas (SMSA's) and counties. Upon approval, these "disaggregations" are then to be used for areawide water quality management planning, facility planning and the "Needs" surveys.

b. Wastewater Flow Estimates

The following flows are to be considered in determining total annual average flows: Annual Average Dry Weather Flows (AADWF) expected from residential sources, nonresidential sources, commercial sources, institutional sources and industries, plus allowances for future industries and non-excessive infiltration/inflow. Methods for determining the amount of infiltration/inflow are given in other EPA publications.

Three methods for estimating AADWF are given in the proposed guidelines. The first method would employ analyses of existing water use records or records of wastewater flows for extended dry periods, less estimated dry-weather infiltration. The present wastewater flow thus obtained would then be converted to a per-capita unit flow (in gallons per capita per day) which would be used to determine the treatment works capacity for some future population.

The second method would allow the State to base its AADWF upon its own developed per-capita wastewater flow allowances, with the approval of the Regional Administrator. These allowances would consider the characteristics of the State and geographic areas within the State.

The third method would make use of previously developed gallons per-capita-per-day flow allowances of 70-90 gpcd. These estimated allowances would include commercial, institutional and residential wastewater sources. Additional allowances for industrial and non-excessive infiltration/inflow would also be included.

It is notable that the proposed regulations state that:

> "Allowances for future increases of per-capita flows over time will not be approved unless a complete justification for such increases is provided and conservation factors...have been fully analyzed...Such conservation factors include water conservation habits induced by future higher water prices, future metering in unmetered areas, trends toward discontinuence of volume discount pricing and more water-efficient plumbing fixtures and appliances in new households."

The guidelines would permit the design capacity treatment works to include an allowance for unforseen future industrial flows as well as for anticipated future industrial flows, although such anticipated capacity needs would have to be documented by letters of commitment. The allowance for future unforeseen flow could not exceed 10 percent of the treatment work's total design flow or 25 percent of the total anticipated industrial flow.

c. Treatment Plant Staging

Two methods are given to determine the initial staging period of treatment plants. The first states that staging periods of 10, 15, and 20 years shall be analyzed and the least-cost period selected. The second method makes use of a previously developed table indicating staging periods based on flow and the flow growth factor (the ratio of the 20-year flow to the initial operating flow). A growth factor exceeding 1.3 could result in a shorter planning period.

d. Interceptor Staging

The Proposed Rules conclude that pipe locations and the staging of pipe lengths are more important than pipe size in influencing growth, monetary costs and creating primary enviromental impacts. Consequently, interceptors could not be extended into undeveloped areas unless necessary to eliminate point-source discharges or to accommodate flows from areas where development is under way.

Pipe sizes would be based on a staging period of 20 to 40 years to be allowable for Federal Funding. Peak flows in interceptors would consider daily and seasonal variations of inflows, timing of inflows, pipe storage, off-pipe storage feasibility and the use of peak flow factors that decrease as the average daily flow increases.

The proposed regulations indicate the following service lives for use in cost-effective analyses:

Conveyance structures	50 years.
Other structures	30 to 50 years.

Finally, it is stated that although flow capacity of planned treatment works may exceed the cost-effective capacity in special cases, grant eligible costs would be reduced. The portion of the project cost which would be deemed eligible for Federal funding would be that proportion of the actual cost times the ratio of the flow capacity of the most cost-effective project to that of proposed project. The costs which would be eligible for grant assistance would be determined by multiplying the actual cost by the ratio of the design flow capacities of the cost-effective project and the proposed project.

It is not known if EPA will actually implement such "proposed regulations." They are similiar to regulations currently in effect in other places where administration of the Clean Water Grant Program has been delegated to the State. Assumptions used in this analysis reflect the Authors' judgement and do not necessarily reflect current or proposed rules and regulations.

C. FEDERAL INTERAGENCY STUDY TEAM ALTERNATIVES (CATEGORY I)

In Category I we present new basic strategies for dealing with the wastewater problems in and around Boston Harbor. The next section will review the EMMA plan, designated Category II. This is followed by ten alternatives to the EMMA plan, designated Category III which employ the same basic assumptions as in the EMMA Report in terms of wastewater flow quantities, strengths, and population served.

The Federal Interagency Study Team Alternatives described in this section are concerned with upgrading the performance of existing facilities with a minimum of expansion. The emphasis is placed on extending the useful life of existing facilities, and determining the effluent quality resulting from rehabilitation and improved operation and maintenance practices as an alternative to constructing new facilities.

As in any case study, certain assumptions are made. In this study, some criteria are not limited by current law or based on constraints in effect at the time of writing.

The basis for these alternatives can be found in the Act itself. As pointed out in Chapter 2 of this report, and again in Section B of this Chapter, the Act requires cost-effectiveness analyses during the Facilities Planning Step of the waste treatment facility for which a grant is requested. Part of this analysis should include an evaluation of improved effluent quality attainable through the upgrading of the operation and maintenance and efficiency of existing facilities. Note that this is to be considered as an alternative or a supplement to construction of new facilities.

Improvement of operations and maintenance of the Deer and Nut Island Treatment Plants has already been discussed in Chapter 2. This section contains alternatives based on facility efficiency improvements principally as a result of not including allowance for excessive increases in flow. This would be effected through conservation measures reducing planned per capita input (as described in Chapter 8), reduction of infiltration/inflow through sewer and interceptor rehabilitation (Chapter 6) and limitations in the extra population to be served by MDC in the future. Limitations on future service would arbitrarily be applied in this study to exclude extra capacity for areas projected to have high rates of growth and/or areas which were not developed in 1972. In Alternative IC, small system technology is applied to communities not presently members of the MSD. Each of these basic criteria will be discussed with the alternatives.

In short, these alternatives are intended to indicate cost-effective facility sizes with sufficent capacity and at the same time avoid overdesign.

All of the Category I alternatives have certain criteria in common. The criteria are based on concepts similar to those included in the proposed EPA Guidelines reported in the previous section, and on actual limitations now in effect in other states to which EPA has delegated administration of the Clean Water Grant Program.

The basic alternatives would upgrade the existing facilities. An allowance is made for rehabilitation and replacement of the older publicly owned sewers to reduce infiltration/inflow. All flows would be handled entirely at the Deer Island and Nut Island Plants. No satellite plants would be needed.

Another item is the service area provided. Although the year 2000 projected sewered populations differ between alternatives, the communities served in the regional system are the same as those now served by the MDC. It is assumed that service to communities not presently members of MSD would not be consolidated into the regional system. No need for extension of sewerage service has been demonstrated. Therefore, the service area of the regional system for would be limited to certain areas of presently sewered MSD member communities.

The following satellite towns which do not have sewers would not be consolidated into the regional system:

Lynnfield
Lincoln
Weston

Dover
Hopkinton
Sharon
Sherborn
Southborough

Sewer service for presently developed areas is assumed to be by individual systems or by facilities provided by the separate communities. In Alternative IC, costs are included for small system wastewater management for the above towns.

Sewer systems for areas developed since the passage of PL 92-500 in October 1972 are assumed in this study to be the responsibility of the developer pursuant to the provisions of PL 92-500, except in Alternative IC.

The only exception we have made to this assumption is to include an allowance in Alternatives IC and ID for the Town of Holbrook which has been a member of MDC since before 1972 but is still not contributing sewage to MDC. Holbrook would not be served by MSD under the assumed criteria for Alternative IA and IB however.

Another item that these alternatives have in common is that secondary treatment additions are not included for the two plants. Therefore this analysis is independent of that requirement of the law.

For the purposes of flow quantification, the average daily dry weather flow is assumed to consist of five components:

(1) Domestic, commercial and institutional
(2) Major industrial
(3) Other industrial
(4) Infiltration
(5) Inflow.

For all these alternatives, the following future average daily dry weather flow components were assumed:

Domestic, commercial, and institutional:	present per capita flows or 85 gpcd, whichever is less for each community
Industrial:	per EMMA Study projections
Infiltration:	30 gpcd

These values are seen as generally compatible with the Proposed Regulations discussed in Section B of this Chapter. The I/I allowance is considered to be a liberal amount to represent leakage in a reasonably well-constructed and well-maintained system. It is used here as a rule-of-thumb average value for new and medium age sewers.

In developing loadings to the plants it was assumed that the per-capita pollutant contributions would remain as at present, unlike EMMA's assumptions. Consequently, the following present contributions, as developed from FY 75-76 MSD data, are used for domestic waste strengths for the year 2000:

Deer Island System:	
BOD	0.28 lb/cap/day
SS	0.28 lb/cap/day
Nut Island System:	
BOD	0.23 lb/cap/day
SS	0.33 lb/cap/day

All loadings and emissions developed in this section and the following sections apply to the year 2000.

In all these alternatives, it is assumed that sludge management will follow the EMMA Recommended Plan regarding primary sludge (Priority Item No. 1). The basis for this is "A Plan for Sludge Management" prepared by Havens and Emerson which recommends sludge processing at both Deer and Nut Islands, and transportation of the digested sludge from Nut Island to Deer Island for disposal. Several sludge management alternatives are being currently considered in the EPA's EIS process as well as by Environmental Research and Technology, consultant to the Federal Interagency Study Team. All the costs presented for the following alternatives include a flow proportional allowance for sludge management, using the amount shown in EMMA as the base cost.

The Category I Alternatives are a "what-if" case study and are not intended to address the same problems that the EMMA Report did. This is particularly the case with respect to the following issues:

(1) The different situations that would have resulted if, starting in 1833, separate sanitary sewers had been constructed and if the very old deteriorated sewers which have served their useful lives had been rehabilited or replaced in a timely manner,

(2) Whether wastewater service areas, flows, and strengths are limited under the Clean Water Grant Program, and

(3) Whether secondary treatment is included.

The cost estimates developed in this case study are based upon arbitrarily assumed conditions simply to enable the Federal Interagency Study Team to see what the results of such assumptions would be and to assess the effects of potential constraints not now applicable. These are not based on current regulations of the Clean Water Grant Program, and are not intended to affect local project planning or implementation.

The new Category I Alternatives are described in the following sections. For each, five kinds of data are presented under the following subheadings:

(1) "Description and Service Provided" gives assumed future service area, population, eligible flow and strength allowances (treatment plant influent loadings), and facilities needed.*

(2) "Items Considered Not Grant Fundable" lists specific constraints and facilities not included in the cost estimates. It is assumed in this case study these items would not receive funding assistance from the Clean Water Grant Program.

(3) "Emissions" tabulates the calculated future quality of treated effluents discharged to Boston Harbor.

(4) "Monetary Costs" gives Capital Cost, Annual O & M Cost, and Present Worth based on the concepts described. Federal, State, and Local Share of grant eligible costs are also given.

(5) "Comparison with EMMA Plan" compares various parameters used in the new alternatives and in the EMMA Recommended Plan.

*(It should be noted that flow quantities shown herein are compatible with the flows used in the report "An Analysis of Water Quality Goals and Objectives")

1. ALTERNATIVE IA, BASIC UPGRADING

a. Description and Service Provided. This alternative would include rehabilitation and upgrading of the present facilities to serve the following loadings from the limited service area to the two present treatment plants:

Item	Deer Island	Nut Island	Total
Sewered Population	1,305,332	735,435	2,040,757
Total ADWF, mgd	215	115	330
Influent Strength			
BOD-mg/l	204	176	
lbs/day	365,000	169,000	534,000
SS-mg/l	204	253	
lbs/day	365,000	243,000	608,000

The population served would be the sum of the lesser of the following for each eligible community.

(1) EMMA projected population for the year 2000, or

(2) The existing population multiplied by 1.3 (representing a moderate population increase). The multiplier represents 30 percent eligible growth in twenty years and is used here for simplification in lieu of using a 10 or 15 year planning period to stage eligible capacity.

Of the forty-three present member communities, about one-half would be affected by having a thirty-percent limit for twenty years of growth. Only presently sewered communities would be served.

The eligible ADWF (in mgd) for purposes of sizing facilities is based on allowances for various wastewater components as follows:

	Average Daily Flow, mgd		
Component	Deer Island	Nut Island	Total
Residential and Commercial	110.9	62.5	173.4
Infiltration/Inflow	39.2	22.0	61.2
Major Industrial	32.4	16.0	48.4
Other Industrial	32.5	14.5	47.0
TOTAL	215.0	115.0	330.0

The total flow, including industrial and I/I allowances is equivalent to 162 gallons per day per person served.

Relief sewers shown in the EMMA Recommended Plan to serve existing sewered areas are included, but the size and cost would be scaled down in proportion to the ratio of limited flows to the flows shown in the EMMA Report.

The industrial flow allowance is the same as the 1970 industrial flow as estimated in the EMMA study.

This alternative assumes the upgrading and rehabilitation of the existing MSD facilities and sewers of member communities. Improvements to the Deer and Nut Island Treatment Plants are also included in Alternative IA. These are:

Deer Island:
(1) Rehabilitation of the eight existing primary sedimentation tanks
(2) Covering of primary sedimentation tanks
(3) Enlargements of outfalls
(4) Chlorination system improvements
(5) Installation of standby power
(6) Miscellaneous features to improve performance, safety, and reliability.

Nut Island:
(1) Construction of relief outfall
(2) Upgrading of chlorination system
(3) Controls improvements
(4) Installation of standby power
(5) Miscellaneous features to improve performance, safety and reliability.

In addition to all primary treatment items in The EMMA Plan at Deer Island and Nut Island, nineteen new interceptor projects and nine new pump station projects as in the EMMA Plan are included, but with costs adjusted to reflect assumed influent characteristics. Furthermore, costs for additional items of work at the existing treatment plants (as noted above) and for some sewer rehabilitation and replacement to reduce excessive I/I are also included although in the EMMA plan.

The cost allowances made herein to reflect reduced I/I are calculated from data in the EMMA Report and in the MDC Annual Report for FY 75-76. These sources give length and size range of publicly-owned sewers of each member community and of the MSD interceptors. Data also shows the percentage of ages of existing sewers classified as new, medium, old, and very old (assumed to influence the amount of I/I) and the percentage of the sewers of each community which are combined. In this Case Study, the following assumptions are made to arrive at an allowance for grant eligible work on existing sewers:

(1) All of the 2,276 miles of sanitary sewers classed as "old" occuring in 33 communities would be lined or otherwise rehabilitated at an average cost of $7.92 per lineal foot.

(2) All of the 817 miles of sanitary sewers classed as "very old" occuring in six communities, would be replaced at an average cost of $15.84 per lineal foot.

(3) All of the 104 miles of MSD interceptors classed as "old" would be rehabilitated at an average cost of $27.72 per lineal foot.

(4) All of the 33 miles of MSD interceptors classed as "very old" would be replaced at an average cost of $79.20 per lineal foot.

(5) It is assumed that the newer pipelines, and all those to be constructed in the future, would have reasonable, non-excessive, I/I.

(6) It is assumed in this study that the portions of the five cities with combined sewers have separate sanitary sewers constructed either prior to the Clean Water Grant Program or outside the grant program because of low positions on priority list.

(7) It is assumed, as is the case locally, that all tidegate rehabilitation work is being locally funded without grant assistance.

b. Items Considered Not Grant Fundable

(1) Service to communities not members of MDC before October 1972.
(2) Service outside present sewered area.
(3) Growth factor in excess of 1.3.
(4) Residential and commercial flow allowance in excess of 85 gpcd.
(5) Wastewater strength in excess of present strength.
(6) Infiltration/Inflow allowance in excess of 30 gpcd.
(7) Combined sewer overflow projects as described in the EMMA report would not be included.
(8) Satellite plants would be unnecessary.
(9) Interceptor extensions would be unnecessary.
(10) No new primary sedimentation tanks would be added.
(11) No secondary treatment facilities would be provided.
(12) No new pumping capacity to serve wet weather flows.
(13) Repair/replacement of private house laterals.
(14) Separating combined sewers, treatment of storm water.

It should be noted that costs to achieve flow reduction are included in the cost of this Alternative but are not included in the Category II and III Alternatives.

The existing sedimentation tanks will provide 98 minutes detention at Deer Island and 92 minutes detention at Nut Island for the average daily flows quantified in Alternative IA.

c. Emissions

The following emissions from the rehabiliated treatment plants to Boston Harbor are expected for the year 2000 with Alternative IA, upgrading but no expansion.

	Deer Island	Nut Island	MSD Total
Flow, mgd	215	115	330
BOD, lbs/day	219,000	120,000	339,000
SS, lbs/day	172,000	109,000	281,000
Primary Sludge Solids Produced, (lbs/day)	194,000	134,000	328,000
BOD Removal, %	40	29	-
SS Removal, %	53	55	-

d. Monetary Costs

In computing the cost of this and all other alternatives in this section, two sources of costs were used. Wherever possible, EMMA costs were used. Where the alternative includes project components not mentioned in EMMA, Kennedy Engineers developed the needed information.

Where the alternative includes an item listed as a priority number under the EMMA Plan, the cost of that item was obtained by applying a factor to the EMMA cost. This factor is related to the ratio of the flow in Alternative IA to that proposed in the EMMA Report, and reflects economics of scale.

The costs of the various components of Alternative IA follows:

	Group	Capital Cost (million)	Annual O & M (million)	Present Worth (million)
1.	I/I Correction	$192.0	0	$102.0
2.	Deer Island Plant Improvements, 1,6*	45.6	6.7	47.3
3.	North System Pump Stations 28, 29, 30, 31	5.2	0.4	3.8
4.	North System Interceptors 4, 21, 24, 27, 33-37, 39, 47, 49-52	35.4	0.1	7.0
5.	Nut Island Plant Improvements, 5	51.8	2.2	41.1
6.	South System Pump Stations 17, 18, 23, 32, 38	6.1	0.5	5.7
7.	South System Interceptors 2, 16, 10A, 11A	68.6+	0.1-	31.5
	Total	$404.8	$ 9.9	$238.4

*EMMA Priority Number

In order for Alternative IA to actually be practical, structural and non-structural measures would have to be implemented to assure that the user does not produce more wastewater than at present. It would not be required that the user produce less. Certain communities would need to reduce I/I. Overall reduction down to one-fourth the I/I projected in the EMMA Report would be necessary and would require partial separation, rehabilitation, and/or replacement of portions of the sewerage systems in the older communities. Amounts to represent work expected to be grant funded are shown in the first line of the table above.* Annual O & M costs are already included for all MDC interceptors being repaired and no annual O & M costs are included for community sewers in order to be consistent with the EMMA study. Eighty-five percent of the amount shown is for fixing local sewers and fifteen percent for MDC interceptors.

As mentioned earlier, these costs reflect a percentage of the cost of the EMMA items applicable to the concepts upon which this alternative is based. No extension of sewers to future member communities is included. Neither are secondary treatment, satellite plants or combined sewer overflow treatment projects. No new sedimentation tanks are to be constructed at the treatment plants.

For all the alternatives in this Chapter, the capital cost responsibility is divided between the Federal (75%), State (15%) and local (10%) financing for that portion of the capital cost that is deemed grant eligible by the EPA. The O & M cost is the sole responsibility of the local agency.

*(The allowance used to replace sewers is $2.64 per inch diameter per foot of length, and half that much to repair them. This is in the range suggested in EPA Technical Report MDC-19.)

Assuming 100 percent grant eligibility of the capital cost of Alternative IA, the cost breakdown would be:

Local Share capital cost	$40.5 million
Annual O & M cost	$ 9.9 million
State Share capital cost	$60.7 million
Federal Share capital cost	$303.6 million
Total capital cost	$404.8 million

e. Comparison With EMMA Plan

The following is a summary of the criteria and cost of Alternative IA compared to the EMMA Recommended Plan which is designated Alternative IIA.

Parameter	Alternative IIA (EMMA)	Alternative IA	IA/IIA, Percent
Communities served	51	42	82
Eligible population	2,440,310	2,040,767	84
Residential & Commercial, mgd	271	174	64
Industrial, mgd	77 (Future)	95 (Present)	123
Infiltration/Inflow, mgd	238	61	26
Total flow, mgd	586	330	56
Per capita flow, gpcd	240	162	68
BOD load, lb/day	855,400	534,000	62
BOD emissions, lb/day	115,700	339,000	293
SS load, lb/day	876,900	608,000	69
SS emissions, lb/day	111,500	281,000	252
Sludge produced, lb/day	818,000	328,000	40
Capital Cost, $ million	855.4	404.8	47
Annual O&M, $ million	25.6	9.9	39
Present worth, $ million	603.0	238.4	40
Federal Share, $ million	641.6	303.6	47
State Share, $ million	128.3	60.7	47
Local Share, $ million	80.5	40.5	47

2. ALTERNATIVE IB, EXPANDED TREATMENT FACILITIES

a. Description and Service Provided

This alternative is similar to IA except that the Deer and Nut Island Treatment Plants would be expanded. A higher level of primary treatment would be provided by adding primary sedimentation tanks to achieve two-hours detention time. This involves the construction of two new sedimentation tanks at Deer Island and two at Nut Island. This would bring the total number of tanks to 10 at Deer Island and 8 at Nut Island. The cost of extra sludge facilities is also included.

As with Alternative IA, no new communities would become MDC members, and only those areas now sewered would be served. Consequently, no extension sewers would be constructed. All other assumptions, flow allowances, populations served, areas served and influent characteristics are the same as for the previous alternative, (total flow 330 mgd). All other project components for the north and south sewerage systems would also be the same as in Alternative IA.

b. Items Considered Not Grant Fundable

(1) Service to communities not members of MDC before October 1972.
(2) Service outside present sewered areas.
(3) Growth factor in excess of 1.3.
(4) Residential and commercial flow allowance in excess of 85 gpcd.
(5) Wastewater strength in excess of present strength.
(6) Infiltration/Inflow allowance in excess of 30 gpcd.
(7) Combined sewer overflow projects as described in the EMMA report would not be included.
(8) Satellite plants would be unnecessary.
(9) Extensions of interceptors would be unnecessary.
(10) No secondary treatment facilities would be provided.
(11) No new pumping capacity to serve wet weather flows.
(12) Repair/replacement of private house laterals.
(13) Separating combined sewers.

c. Emissions

As a result of increased settling time to 120 minutes, the following emissions to Boston Harbor and sludge production are estimated:

	Deer Island	Nut Island	Total
Flow, mgd	215	115	330 BOD,
lbs/day	215,000	117,000	329,000
SS, lbs/day	146,000	102,000	248,000
Sludge Solids Produced, lbs/day	219,000	141,000	360,000
BOD removed, %	41	31	-
SS removal, %	60	58	-

We would also expect better grease removal and slightly better disinfection with the expanded facilities, compared with use of the existing facilities.

d. Monetary Costs

Our procedure for costing is identical to that already described. The differences in the costs between Alternatives IA and IB reflect only added primary sedimentation tanks and primary sludge facilities.

Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1. I/I Correction	$192.0	0	$102.0
2. Deer Island System (As per Alt. IA and additional improvements to plant)	$ 93.1	$ 8.2	$ 63.1
3. Nut Island System (As per Alt. IA and additional improvements to plant)	$132.4+	$ 3.0	$ 83.0
TOTAL	$417.6	$11.2	$248.1

As with the previous alternative, the capital cost should be 100 percent grant eligible, since the total flows are the same. Consequently, the cost responsibility is:

Local Share - capital cost	$41.8 million
O&M cost	$11.2 million
State Share - capital cost	$62.6 million
Federal Share - capital cost	$313.2 million
Total - capital cost	$417.6 million

e. Comparison With EMMA Plan

The following is a summary of the criteria and cost of Alternative IB compared to the EMMA Recommended Plan. (Communities, population, flows and loads under Alternative IB are the same as for Alternative IA).

Parameter	Alternative IIA (EMMA)	Alternative IB	IB/IIA Percent
BOD emissions, lb/day	115,700	332,000	287
SS emissions, lb/day	111,500	248,000	222
Sludge produced, lb/day	818,000	360,000	44
Capital Cost, $ million	855.4	417.6	49
Annual O & M Cost, $ million	25.6	11.2	44
Present Worth, $ million	603.0	284.1	41
Federal Share, $ million	641.6	313.2	49
State Share, $ million	128.3	62.6	49
Local Share, $ million	85.5	41.8	49

3. ALTERNATIVE IC, UNLIMITED GROWTH

a. Description and Service Provided

Alternative IC further expands the existing MSD facilities and service area to serve the year 2000 population and industrial loadings as projected by EMMA in the existing member communites. Because industrial loadings decrease, the resulting total flow at Deer Island is slightly smaller than Alternative IA. However, no new communities are consolidated into the regional system, so only those extension sewers in the EMMA Plan to service existing MSD members are included. Instead, the new communities would be served by small systems appropriate technology, under regional management, and thus the total population served would be the same as in the EMMA Plan.

At the Harbor Treatment Plants, two new sedimentation tanks would be constructed at each plant to provide 2 hours detention. Other improvements to the plants are included in EMMA Priority Items No. 5 and 6, as well as other improvements listed for Alternative IA.

The service area in this Alternative is assumed to be extended into the eight new communities which are not MSD members by the creation of a hypothetical septic tank maintenance agency. Said agency would provide new septic tanks as growth occurs, provide a new leach field every ten years, and operate, monitor, and maintain the individual systems. For purposes of this study, it is assumed that this type of sewerage service perhaps with regional management, would be grant eligible. The eight communities have a year 2000 population of 62,334 persons in need of sewerage service, according to the EMMA Report. If sewered, they would contribute an ADWF of 8.55 mgd, equivalent to 137 gpcd, as follows:

Residential and Commercial	5.80
Industrial	0.90
I/I	1.85
Total	8.55 mgd

The following characteristics are assumed:

Item	Deer Island	Nut Island	Total
Sewered Population	1,425,084	952,900	2,377,984
Non-sewered Population	35,324	27,010	62,334
Total Population Served	1,460,408	979,910	2,440,318
Sewered ADWF (mgd)	212	136	348
Non-sewered Flow (mgd)	5	4	9
Equivalent Flow (mgd)	217	140	357
Influent To Plants			
BOD-mg/l	226	193	-
lbs/day	399,000	219,000	618,000
SS-mg/l	226	277	-
lbs/day	399,000	315,000	714,000

The flow of 348 mgd is used in this case study as a baseline amount to determine the size of regional facilities needed.

Flow quantification based on unlimited growth in the present MSD member communities, but with limited per capita flows, results in the following:

	Average Daily Flow, mgd		
Component	Deer Island	Nut Island	Total
Residential and Commercial	121	81	202
Industrial	48	27	75
I/I allowance	43	28	71
Total	212	136	348

The implication of this amount of flow is the concept that treatment works should be designed to provide at least the capacity determined in a cost-effective load-quantification analysis. However, the portion of the cost allocable to the capacity in excess of the cost-effective size would not be grant eligible, and the local agencies would be responsible for fully financing any extra capacity they may choose to provide. An option open to the community would be to implement measures to reduce the flow to the eligible amount.

Specifically, the grant eligible cost would include cost to provide capacity not in excess of the projected population with associated commercial establishments and public institutions within the service area projected over a reasonable length of time. Also included would be flows from present industrial establishments and non-excessive I/I. Alternative IC closely satisfies the requirement of cost-effectiveness, and would serve the same area and population as the proposed EMMA Plan. The design capacity of this alternative is used later in this Chapter in determining proportionate eligible costs through reduced eligibility. Treatment level in this alternative would be higher than at present but would not meet secondary treatment requirements. The average daily dry weather flow of all facilities in the EMMA plan is 586.2 mgd of which 8.6 is allotted to the eight satellite communities not presently MSD members. The flow in the regional system of Alternative IC is 348.0 mgd. Therefore, the ratio of the sewered area flows in Alternatives IC and IIA is 348.0/586.2-8.6 = 0.6025, or 60.25 percent.

b. Items Considered Not Grant Fundable

(1) Residental and commerical flow allowance in excess of 85 gpcd.
(2) Wastewater strength in excess of present strength.
(3) Infiltration/inflow allowance in excess of 30 gpcd.

(Continued on the next page)

(4) Combined sewer overflow projects.
(5) Satellite plants.
(6) Interceptor extensions.
(7) Secondary treatment facilities.
(8) New pumping capacity for wet weather flows.
(9) Repair/replacement of private house laterals.
(10) Separating combined sewers.

It should be noted that interceptor extensions and sewer for the eight satellite communities are not needed in this Alternative, and that the cost of needed sewers are not included in the Category II and III Alternatives.

c. Emissions

The following emissions and sludge production are estimated for this alternative.

	Deer Island	Nut Island	Total
Flow, mgd	212	136	348
BOD, lbs/day	235,000	149,000	384,000
SS, lbs/day	160,000	129,000	289,000
Sludge Solids Produced, lbs/day	239,000	186,000	425,000

Plant performance is assumed to be the same as in Alternative IB.

d. Monetary Costs

The costs for Alternative IC were computed in a similar manner as for previous alternatives, reflecting a percentage of the cost of the EMMA items applicable. In addition to the EMMA items and improvements to Deer and Nut Island considered previously, this alternative includes extension sewers to serve existing MSD communities in the year 2000. As before, costs for secondary treatment, satellite plants, combined sewer overflow facilities and sewer separation are not included in this cost estimate. Two new sedimentation tanks would be added at each of the plants. Following are the component costs of Alternative IC.

Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1. I/I/ Correction	$192.0	0	$102.0
2. Deer Island System (EMMA priority numbers 1,4,6,21,22,24-31, 33-37,39,46,47, 49-52, and improvements to plant)	$94.0	$8.1	$62.6
3. Nut Island System (EMMA priority numbers 2,5,14,16-20,23,32,38, 35,38,45,48,10A,11A, and improvements to plant)	$182.6	$3.6	$113.9
4. Service for new member communities	$ 20.4	$0.6	$ 8.2
Total	$489.0	$12.3	$286.7

Under 100 percent grant eligibility of capital costs, the cost responsibility would be as follows:

Local Share - capital cost	$48.9 million
annual O&M cost	$12.3 million
State Share - capital cost	$73.4 million
Federal Share - capital cost	$366.7 million
Total - capital cost	$489.0 million

e. Comparison With EMMA Plan

The following is a summary of the criteria and cost of Alternative IC compared to the EMMA Recommended Plan.

Parameter	Alternative IIA (EMMA)	Alternative IC	IC/IIA Percent
Communities Served:			
Regional System	51	43	
Septic System	_	8	
Total	51	51	100
Eligible Population:			
Regional System	2,440,318	2,377,984	
Septic System	-	62,334	
Total	2,440,318	2,440,318	100
Flows, mgd			
Residential and Commercial	271	202	
Industrial	77	75	
Infiltration/Inflow	238	71	
Equivalent Septic	-	9	
Total	586	357	61
Per capita flow, gpcd	240	146	61
Waste characteristics at treatment plants, lbs/day			
BOD load	855,400	618,000	72
BOD emissions	115,700	384,000	332
SS load	876,900	714,000	81
SS emissions	111,500	289,000	259
Sludge produced	818,000	425,000	53
Costs, $ million			
Capital	855.4	489.0	57
Annual O & M	25.6	12.3	48
Present Worth	603.0	286.7	48
Federal Share	641.6	366.7	57
State Share	128.3	73.4	57
Local Share	85.5	48.9	57

A further comparison can be made of the cost to serve the 62,334 persons in the eight satellite communities by consolidation and by regionally managed septic systems. Under the assumptions of this case study, the average per capita costs of service are as follows:

Per capita Cost	Alternative IIA (EMMA)	Alternative IC Septic Syst.	IC/IIA Percent
Capital Cost	$351	$327	93
Annual O & M Cost	11	10	92
Present Worth	247	132	53
Federal Share	263	245	93
State Share	53	49	93
Local Share	35	33	93

It should be noted that the Alternatives in Categories II and III do not include costs to construct, operate, and maintain sewers, which are not needed in Alternative IC for new member communities.

4. ALTERNATIVE ID, WITH COMBINED SEWAGE FLOWS

a. Description and Service Provided

This alternative is a basic building block with various additions to handle wet weather flows from combined sewer areas tributary to Deer Island. Combined sewage would be retained and not allowed to overflow, with the provision of extra facilities at Deer Island to treat the stored combined sewage during dry-weather. Other alternatives are being studied by Environmental Research and Technology (ERT), including:

(1) Automatic dry-weather flushing of combined sewer deposits with extra primary treatment at Deer Island,
(2) Separate storage and treatment of urban stormwater, and
(3) Street cleaning for urban runoff source control.

All are optional strategies in lieu of overflow facilities for which the EMMA Study budgeted $270 million.

In Alternative ID, the service area and population served is that forecasted for the year 2000 in the EMMA Report for existing member communities. Therefore no new communities would be eligible for participation.

The industrial flow allowance is that forecasted for the year 2000 by EMMA and inflow to Deer Island is taken to be 100 mgd. This amount was derived by ERT to be the amount of additional flow that can be carried by the interceptors to the Deer Island headworks. Consequently 100 mgd represents the additional capacity required at Deer Island to treat the wet weather flow component.

Provision is again made for two hours sedimentation time at Deer and Nut Island. This requires two new tanks at Nut, and seven at Deer Island. Other improvements to the plants were listed in Alternative IA.

The influent to the plants is estimated to have the following characteristics:

Item	Deer Island	Nut Island	Total
Sewered Population	1,425,084	952,900	2,377,984
Total ADWF, mgd	312	136	448
Influent Strength			
BOD-mg/1	226	193	-
lbs/day	588,000	219,000	807,000
SS-mg/1	226	277	-
lbs/day	588,000	315,000	903,000

Flow quantification is based on the same assumptions as Alternative IC, but with the added wet weather component as follows:

	Average Daily Flow, mgd		
Component	Deer Island	Nut Island	Total
Residential/Commercial	121	81	202
Industrial	48	27	75
I/I Allowance	143	28	171
Total	312	136	448

b. Items Considered Not Grant Fundable

(1) Service to communities not MDC members.
(2) Residential and commercial flow allowance in excess of 85 gpcd.
(3) Wastewater strength in excess of present strength
(4) Satellite Plants
(5) Interceptor extensions
(6) Secondary treatment facilities
(7) Sewer separation

c. Emissions

Alternative ID is expected to produce the following emissions and sludge quantities:

	Deer Island	Nut Island	Total
Flow, mgd	312	136	448
BOD lbs/day	341,000	149,000	
SS, lbs/day	276,000	129,000	
Sludge Solids Produced, lbs/day	312,000	186,000	

d. Monetary Costs

Costs for the work in Alternative IC are:

(1)	Capital Cost	$468.6 million
(2)	Annual O & M Cost	$ 11.7 million
(3)	Present Worth	$278.5 million

The difference in costs between this alternative and the relevant portion of Alternative IC results from:

(1) The additional sedimentation tanks to be constructed at Deer Island, and
(2) A larger percentage of the costs of the applicable EMMA items in the Deer Island system due to the larger flows involved.
(3) No costs for service in non-member communities.

All other EMMA items, improvements and limitations of the costs presented are as described for Alternative IC.

Group	Capital Cost (million)	Annual O & M (million)	Present Worth (million)
1. Deer Island System (As per Alt. IC and additional improvements to plant)	$169.5	$ 17.1	$115.0
2. Nut Island System (As per Alt.IC)	$182.6	$ 3.6	$113.9
TOTAL	$352.1	$ 20.7	$228.9

The following breakdown of cost responsibility would result from 100 percent grant eligibility:

Local Share - capital cost	$35.21 Million
- annual O&M cost	$20.70 million
State Share - capital cost	$52.81 million
Federal Share - capital cost	$264.07 million
Total - capital cost	$352.09 million

e. Comparison With EMMA Plan

It is of interest to compare the incremental cost of combined sewage treatement under this alternative with the proposal in the EMMA Recommended Plan. To review, the EMMA Plan proposes the building of four groups of facilities to regulate combined sewer overflows in the Deer Island system prior to discharge into inland waters. The estimated capital cost of that plan is $270 million, based on a total combined sewage handling capability of up to 8,400 mgd.

The incremental cost of combined sewage treatment under Alternative ID is the difference in costs between this alternative and costs of portions of Alternative IC.

A comparison of incremental costs for the CSO management only, between the EMMA Recommended Plan and Alternative ID, follows:

Item for CSO Management	EMMA Recommended Plan Cost (million)	Alternative ID Cost* (million)
Capital Cost	$270	$75.5
Annual O&M	$ 3.9	$ 9.0
Present Worth	$175.8	$52.4

* Obtained by subtracting the relevant costs of Alternative IC from Alternative ID.

Combined sewage would need to be stored in Alternative ID. No costs for storage outside existing combined sewers is included.

D. EMMA RECOMMENDED PLAN (CATEGORY II)

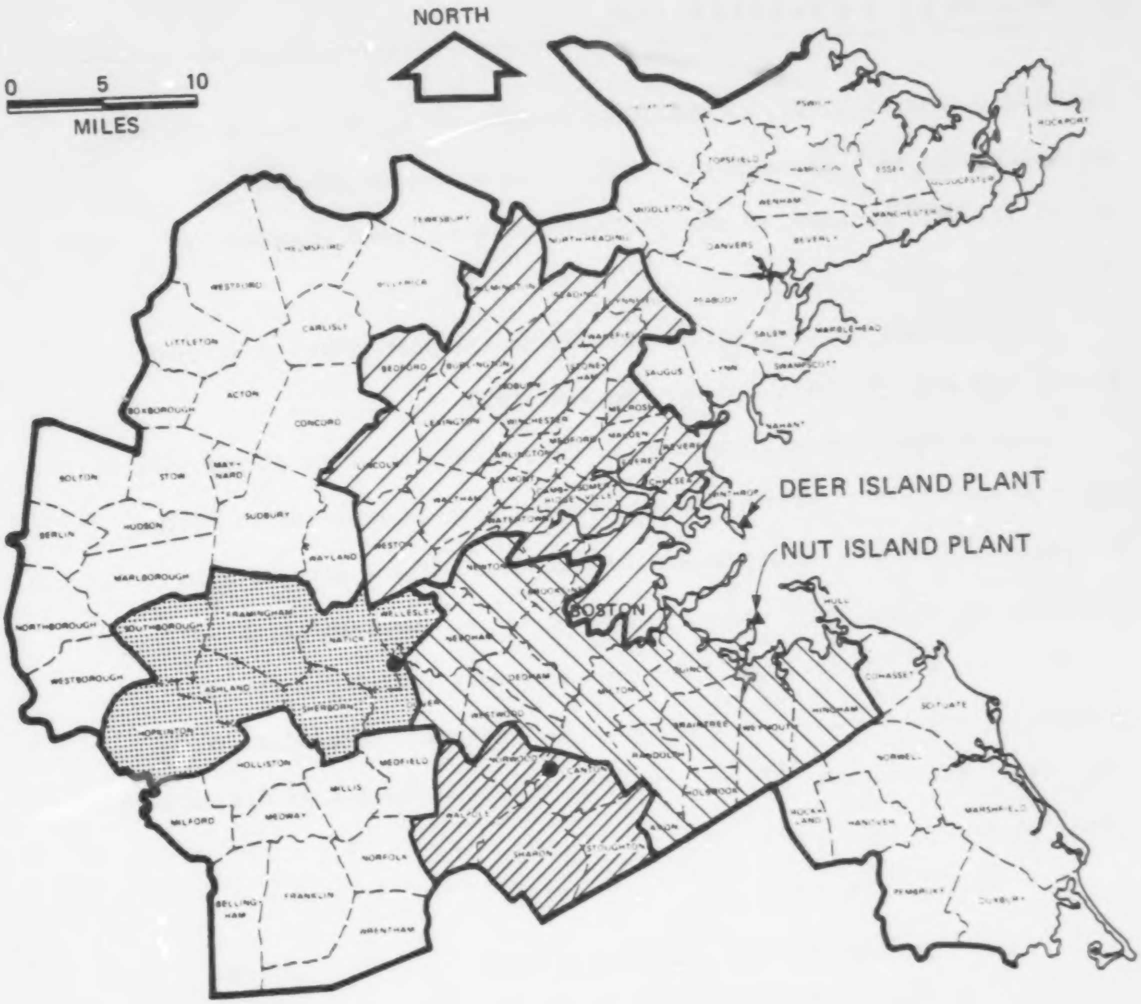
The EMMA Recommended Plan has been accepted locally as the Basin Plan for purposes of defining the basic plan for future wastewater facilities. The future actions described in the EMMA Report have been agreed upon by the regulatory agencies in Boston. In this Case Study the EMMA Recommended Plan, as outlined in our Chapter 3, is reviewed for further examination and will also be the point of departure for consideration of other alternatives defined in Category III.

The future expanded service area would include most of the communities tributary to Boston Harbor. The remaining (peripheral-area) communities are mostly outside the Boston Harbor drainage basin and are assumed excluded from the regional system as a given in this alternative.

Population, loadings, emissions, and costs for the expanded metropolitan systems are shown in Chapter 3 summarized herein. Note that two new satellite AWT (tertiary) plants with separate discharges are also givens in the Recommended Plan.

Major combined sewer overflows would be consolidated into four geographical groups with minimally treated intermittent discharges under the plan included in the EMMA Report. We have been assured by MDC however that they are not bound by the EMMA Recommended Plan and may implement other types of systems as may be determined cost-effective during the Step 1 planning process.

The assumed future service areas of the four treatment plants in the EMMA Recommended Plan are shown on Figure 10-1. The approximate locations of the plants are also shown. There would be two large plants discharging secondary effluent into the Boston Harbor and two smaller plants discharging tertiary effluent into the Upper Neponset River and


NORTH
0
5
10
MILES
DEER ISLAND PLANT
NUT ISLAND PLANT
BOSTON
TEWKSBURY
CHELMSFORD
WESTFORD
BILLERICA
CARLISLE
LITTLETON
BOXBOROUGH
ACTON
CONCORD
BEDFORD
BURLINGTON
WOBURN
LEXINGTON
WINCHESTER
LINCOLN
ARLINGTON
BELMONT
WALTHAM
WATERTOWN
WESTON
BOLTON
STOW
MAY-
NARD
SUDBURY
BERLIN
HUDSON
MARLBOROUGH
WAYLAND
NORTHBOROUGH
SOUTHBOROUGH
FRAMINGHAM
NATICK
WELLESLEY
WESTBOROUGH
ASHLAND
SHERBORN
HOPKINTON
HOLLISTON
MEDFIELD
MILLIS
MILFORD
MEDWAY
NORFOLK
BELLING-
HAM
FRANKLIN
WRENTHAM
NEWTON
BROOKLINE
NEEDHAM
DEDHAM
WESTWOOD
MILTON
QUINCY
BRAINTREE
WEYMOUTH
HINGHAM
RANDOLPH
HOLBROOK
NORWOOD
CANTON
WALPOLE
SHARON
STOUGHTON
AVON
HULL
COHASSET
SCITUATE
NORWELL
ROCK-
LAND
HANOVER
MARSHFIELD
PEMBROKE
DUXBURY
NORTH READING
READING
WAKEFIELD
STONE-
HAM
MELROSE
MEDFORD
MALDEN
REVERE
EVERETT
CHELSEA
CAMB-
RIDGE
SOMER-
VILLE
WINTHROP
SAUGUS
LYNN
SWAMPSCOTT
NAHANT
PEABODY
SALEM
MARBLEHEAD
MIDDLETON
DANVERS
BEVERLY
TOPSFIELD
WENHAM
HAMILTON
ESSEX
MANCHESTER
GLOUCESTER
ROCKPORT
IPSWICH

LEGEND

- ▨ DEER ISLAND SERVICE AREA
- ▧ NUT ISLAND SERVICE AREA
- ▨ UPPER NEPONSET SERVICE AREA
- ░ MIDDLE CHARLES SERVICE AREA
- ▲ SECONDARY PLANT
- ● AWT PLANT

NSF Boston Case Study, Phase II Evaluation

PLANT SERVICE AREAS
IN RECOMMENDED PLAN
YEAR 2000

Kennedy Engineers, Inc. Figure **10·1**
1977

Basemap: EMMA Report

the Middle Charles River, as described in Chapter 3. We assumed project implementation in accordance with the MDC construction schedule of August 31, 1976 pursuant to the EPA/DWPC/MDC Enforcement Compliance Schedule Letter.

The assumed planning period extends to the year 2000. Some projected criteria, however, are for the year 1990.

We make these assumptions for the Case Study, in spite of the fact that the form of the actual EMMA Recommended Plan is expected to change during the facilities planning and environmental impact process when solutions to unresolved problems are selected for implementation.

In both the EMMA recommended plan (Alternative IIA) and the modified plan (Alternative IIB), sludge handling is assumed to conform to "A Plan for Sludge Management", and that the present practice of discharging sludge to Boston Harbor will be discontinued.

1. ALTERNATIVE II A

a. Description and Service Provided

This alternative is the EMMA plan exactly as presented in Chapter 3 and the EMMA report. The pertinent features of the plan are reviewed below.

The EMMA Recommended Plan consists of five categories of 52 total projects. These include expansion and rehabilitaion of the Deer Island System, expansion and rehabilitation of the Nut Island System, construction of the Middle Charles River satellite plant, construction of the Upper Neponset River satellite plant, relief and extension interceptors, pump stations, and combined sewer overflow projects.

The projected population, service area and influent characteristics of the four treatment plants follow:

	Deer Island	Nut Island	Middle Charles	Upper Neponset	Total
Service Area sq. miles	137	91	38	27	293
Population, yr. 2000	1,460,408	674,910	181,000	124,000	2,440,318
Flow, mgd	400	130	31	25.2	586.2
BOD, mg/1	166	185	222	200	----
-1bs/day	555,000	201,000	57,400	42,000	855,400
SS, mg/1	153	259	183	178	----
-1bs/day	511,000	281,000	47,400	37,500	876,900
NH_3-N mg/1	----	----	21.0	----	
-1bs/day	----	-5,430	4,4----		
Total P, mg/1	----	----	12.0	12.4	----
-1bs/day	----	----	3,100	2,600	----

These influent loadings were derived from future per-capita flow and per-capita loading assumptions made in the EMMA study. These assumptions are tabulated in Table 10-1.

b. Items Considered Not Grant Fundable

The EMMA Plan includes major regional facilities for the wholesale treatment of Wastewater and combined sewage. All items are probably considered eligible for grant funding. No costs are included for sewers nor for sewer rehabilitation or replacement, as the regional agency indicates this item is a local community problem.*

*(MDC advises that a program to reduce wastewater flows requiring treatment is beyond MDC's jurisdiction and contrary to federal law.)

c. Emissions

Details of projected emissions from EMMA Plan plants are given in Chapter 3, and are summarized below:

	Discharges for Year 2000		
Parameter	To Boston Harbor	To Rivers	Total
Flow, mgd	530	56.2	586.2
BOD, lbs/day	113,400	2,350	115,750
SS lbs/day	109,200	2,350	111,550
NH3-N, lbs/day	-	470	-
Total P, lbs/day	-	470	-
Sludge Produced, lbs/day	688,000	130,000	818,000

TABLE 10-1

FLOW QUANTIFICATION AND LOADINGS ASSUMED IN THE EMMA STUDY

	Deer Island		Nut Island		Satellite Communities		Total
	1970	2000	1970	2000	1970	2000	2000
Average Flow From							
Existing MSD Communities							
Residential/Commercial	122.0	177.3	41.2	60.3	0	26.7	264.3
Infiltration mgd	125.1	128.5	47.4	45.2	0	13.0	186.7
Industrial, major mgd	32.4	32.8	16.0	7.0	0	9.0	48.8
Industrial, other mgd	32.5	15.2	14.5	6.7	0	4.0	25.9
Inflow Allowance mgd	N/A	41.3	N/A	10.8	0	0	52.1
Flow from 8 added communities	0	4.9	0	0	0	3.5	8.4
Total, mgd	312	400	120	130	0	56.2	586.2
Gal/cap/day (Total)	233	274	190	193	0	185	240
Gal/cap/day (Without I/I & Ind.)		125		89		99	112
Loading Allowances							
BOD (lbs/cap/day)	0.33	0.38	0.24	0.30	-	.33*	
S.S. (lbs/cap/day)	0.28	0.35	0.35	0.42	-	0.28*	

*Satellite area loadings approximated by estimating populations.

d. Monetary Costs

As discussed earlier, the EMMA Recommended Plan consists of five categories of projects. The projected costs of the projects, including Kennedy Engineers estimates of present worth, follow:

Group	Capital Cost (million)	Annual O&M Cost (million)	Present Worth (million)
1. Deer Island System	$302.553	$12.351	$224.317
2. Nut Island System	$147.736	$ 4.107	$101.886
3. Middle Charles River System	$ 78.941	$ 2.841	$ 58.148
4. Upper Neponset River System	$ 56.129	$ 2.373	$ 42.768
5. Combined Sewer Overflow Projects	$270.000	$ 3.900	$175.837
TOTAL	$855.359	$25.572	$602.956

e. Assumed Funding

(1) If one assumes that the EMMA plan would be 100 percent eligible for grant funding, the cost breakdown would be:

Local Share - capital cost	$ 85.5 million
- Annual O&M cost	$ 25.6 million
State Share - capital cost	$128.3 million
Federal Share - capital cost	$641.6 million
Total - capital cost	$855.4 million

(2) The flows in Alternative IC are 60.25 percent of the flows in the EMMA Plan. If the capital cost of the EMMA Plan were only 60.25% grant eligible, the grant eligible portion would be only $515.4 million and the ineligible portion would be $340.0 million.

The cost breakdown would become:

Local Share - capital cost	$391.5 million
- annual O&M	$ 25.6 million
State Share - capital cost	$ 77.3 million
Federal Share - Capital cost	$386.6 million
Total capital cost	$855.4 million

The local share of capital cost is the sum of 10% of the eligible cost plus 100% of the ineligible cost.

This assumes that costs for excess capacity would be locally funded. Some items labeled grant ineligible actually may be eligible but would not receive funds due to low position on priority list and the demand for funds exceeding the supply.

2. ALTERNATIVE IIB

Under this alternative, additional modifications and rehabil0 itation would be performed at the Deer and Nut Island Treatment Plants. However no change is anticipated in service, area, population, flows, influent strength or effluent strength from the EMMA plan. These values can be found in the previous section. The only change will be in the costs to reflect the additional modifications.

a. Modifications and Monetary Costs

(1) Deer Island Treatment Plant

At Deer Island, the following additional modifications would be performed:

(a) New Boston Main Interceptor pump station
(b) Rehabilitation of existing eight primary sedimentation tanks.
(c) Covering of existing tanks.
(d) Addition of 5 additional primary sedimentation tanks (above the 6 proposed by EMMA) to achieve two hours primary detention.
(e) Covering of all new tanks.
(f) Extension of outfalls.
(g) Upgrading of chlorination system.
(h) Installation of stand-by power.
(i) Other features to provide increased performance, reliability and safety.

The total capital cost of the above comes to $90.58 million. This increases the capital cost of EMMA Priority Item No. 6 to $132.4 million and the operation and maintenance cost to $19.25 million. All other costs in the Deer Island system remain the same.

(2) Nut Island Treatment Plant

The additional modifications to be performed at Nut Island are as follows:

(a) Construction of relief outfall.
(b) Upgrading of chlorination system.
(c) Controls improvements.
(d) Installations of standby power.
(e) Other features to improve performance reliability, and safety.

The total of the above come to $13.7 million which increases the total capital cost of EMMA Priority Item No. 5 to $64.2 million. The operation and maintenance cost becomes $2.58 million. As a result of the above changes, the total cost for Alternative IIB is:

Group	Capital Cost (million)	Annual O&M Cost (million)	Present Worth (million)
1. Deer Island System	$393.1	$25.5	$264.0
2. Nut Island System	161.4	4.7	112.5
3. Middle Charles R. System	78.9	2.8	58.2
4. Upper Neponset R. System	56.1	2.4	43.8
5. Combined Sewer Projects	270.0	3.9	175.8
Total	$959.6	$39.3	$653.3

b. Assumed Funding

(1) Assuming 100 percent grant eligibility, the cost responsibility would be as follows:

Local Share - capital cost	$ 96.0	million
annual O & M	$ 39.3	million
State Share - capital cost	$143.9	million
Federal Share - capital cost	$719.7	million
TOTAL capital cost	$959.6	million

(2) The flows in Alternative IC are 60.25% of the EMMA Plan. If the capital cost of Alternative IIB were only 60.25% grant eligible, then the grant eligible cost would be $578.4 million and the grant ineligible cost would be $381.4 million. The cost breakdown would become:

Local Share - capital cost	$439.2	million
annual O & M	$ 39.3	million
State Share - capital cost	$ 86.7	million
Federal Share - capital cost	$433.7	million
TOTAL capital cost	$959.6	million

c. Comparison With EMMA Plan

There are several potential advantages of alternative IIB over IIA. There are the benefits stemming directly from the improvements mentioned above. These include greater pumping capacity (leading to fewer overflows), more reliability with the primary tanks covered at Deer Island with fewer corrosion and icing problems, greater effluent dilution because of lengthened outfalls, a reduction in work hazards due to safety improvements, and more effective scum removal and chlorination, among others.

There are other benefits derived from adding additional primary sedimentation tanks at Deer Island. Increasing sedimentation time from 92 to 120 minutes should improve BOD and suspended solids removals resulting in more economical and less energy-intensive secondary treatment. The sizes of the aeration tanks could be 5% (3 million gallons) smaller in volume.

Increasing the detention time in the primaries would result in the same amount of sludge to be digested and disposed of. However, approximately 5000 lbs/day more primary sludge and 5000 lbs. per day less secondary sludge would be produced at the longer detention time. Because primary sludge is more dense than secondary sludge, the total volume of sludge produced decreases as the settling time increases. Sludge handling costs, related to volumes, would be less.

3. STAGING THE SECONDARY TREATMENT FACILITIES

We have discussed earlier that the costs are at the 1975 price levels and the present worth is dependent upon the date of planned construction.

We have re-worked the present worth of the EMMA Recommended Plan based upon deferring three projects related to secondary treatment for a period of twelve years. All other projects would be implemented exactly in conformance with the MDC Schedule. The three projects are:

Priority No.	Description
7	Nut Island Secondary Treatment
8	Deer Island Secondary Treatment
9	Secondary Sludge Management

A comparison of the costs for those items based on two schedules for implementing secondary treatment, disregarding inflation, is given below in million dollars:

Schedule	Capital Cost	Annual O&M Cost	Present Worth
EMMA	264.8	5.5	176.0
Delay 12 years	264.8	5.5	38.1
Reduced Cost	0	0	137.9

Although this analysis, made in accordance with present EPA criteria, shows a cost reduction, a more realistic analysis considering probable inflation of seven percent per year and disregarding salvage, would probably show no difference.

The above analysis was made in accordance with current EPA criteria. The results are erroneous. The use of a constant planning period results in only three years of operation to be included in the delayed program where fifteen years is included in the EMMA Schedule, giving a low present worth of annual costs. Furthermore, a more realistic analysis considering probable inflation in an amount equal to the interest rate would give no reduction in present worth of the capital cost by delaying the scheduled projects.

E. ALTERNATIVES TO THE EMMA RECOMMENDED PLAN (CATEGORY III)

Ten alternatives to the EMMA Recommended Plan are presented for consideration. In each, the expanded service area is assumed to remain the same, as will the planning period population and projections of loadings for comparative analysis.

All alternatives involve the southern service area of the Metropolitan Sewerage District now served by the Nut Island Plant. Whether the future southern treatment plant is actually located on Nut Island, or some other nearby location, is immaterial because the loadings, emissions and location of discharge points would be the same. The satellite plants are also not site-specific in this study.

Alternatives IIIJ and IIIK involve the Deer Island facilities in addition to Nut Island and southern service area facilities. Data on alternative project criteria, amount and location of emissions, quantities of loadings, cost data and benefits are presented in this section for comparison with the EMMA Recommended Plan.

Some of the alternatives involve the degree of treatment to be provided at the existing and proposed treatment plants, and most of them provide alternatives regarding the extent of consolidation of the satellite communities.

The towns identified as satellite communities and the watershed in which they are located are given below:

Town	Present MSD Member	Middle Charles River	Upper Neponset River
Ashland	Yes	X	X
Canton, north half	Yes		X
Framingham	Yes	X	
Natick	Yes	X	
Norwood	Yes		X
Stoughton	Yes		X
Walpole	Yes		X
Wellesley	Yes	X	
Dover, west half	No	X	
Hopkinton	No	X	
Sharon	No		X
Sherborn	No	X	
Southborough	No	X	
Total		8	5

The need for, and level of, treatment required at the satellite AWT plants is presumed to be adequate, as defined in the EMMA Recommended Plan based upon the following reasoning:

NPDES permit No. MA 0102351 issued to the Metropolitan District Commission, August 12, 1976, reference 10.4, states:

> "Satellite Wastewater Treatment Plants"
>
> If the option to build satellite advanced wastewater treatment plants is selected based on the Environmental Impact Statement, as a minimum, the following should be followed:
>
> a. After May 1, 1984, the permittee, if the project is approved, will be authorized to discharge from the Middle Charles River Wastewater Treatment Plant an effluent to the Charles River whose characteristics shall be capable of meeting load allocations as developed in the water quality management plan for the Charles River, in accordance with section 303(e) of the Federal Act.
>
> b. After May 1, 1984, the permittee, if the project is approved, will be authorized to discharge from the Upper Neponset

> Wastewater Treatment Plant an effluent to the Neponset River whose characteristics shall be capable of meeting load allocations as developed in the water quality management plan for the Neponset River, in accordance with section 303(e) of the Federal Act."

It should be noted that the EMMA Recommended Plan, accepted by the State and EPA, provides for construction of satellite AWT plants on the Middle Charles River and the upper Neponset River without specifying the effluent level to be provided for discharge to these rivers. It appears that the Neponset River Plant (and possibly the Charles River Plant) may be prohibited under the Water Quality Standards as approved by EPA, from discharging into these water quality limited rivers above existing discharges.

According to the 1976 "Classification and Segmentation of Massachusetts River Basins and Coastal Zones," the segments of the rivers in the vicinity of the satellite plants are classified as water quality limited, reference 10.6. Discharges into them, as proposed in the EMMA Recommended Plan, would require a higher degree of treatment than secondary, if not prohibited.

A treatment plant similarly situated, but with the effluent conveyed to Boston Harbor, would not need to provide advanced waste treatment. The change in the point of discharge in Alternatives IIIB and IIIE could be the key to avoiding more stringent treatment and would comply with the laws. The change in the point of discharge also is essentially the same as under Alternatives IIIA and IIIK with consolidation of treatment at Nut Island.

The previously cited NPDES permit confirms that the effluents would need to meet load allocations as developed in the basin plans. Such load allocations have not been made in the EMMA Report, which was accepted as the basin plan.

Because the EMMA Report has been adopted by the Regional Administrator as the basin plan (as documented in Chapter 3), one may therefore presume that the effluent criteria for AWT published in the EMMA Report (pages 3-32) are acceptable to the Enforcement Division of EPA.

A minimum of secondary treatment would be provided in all Category III alternatives except Alternatives IIIJ and IIIK which would provide primary treatment only.

All of the category III alternatives (as well as the Category II alternatives) are based on criteria in the EMMA Report to serve the unlimited population growth in the present member communities, as would be served by Alternatives IC and ID. In addition, however, the Category II and III alternatives are sized to served additional population in eight future member communities as follows:

Service Area	Population
Deer Island	35,324
Nut Island	27,010
Total Additional	62,334 persons

All of the Category III alternatives, like the Category II alternatives, have provision for $270 million worth of combined sewer overflow facilities and none of the category II or III alternatives include the cost of I/I correction or sewer rehabilitation.

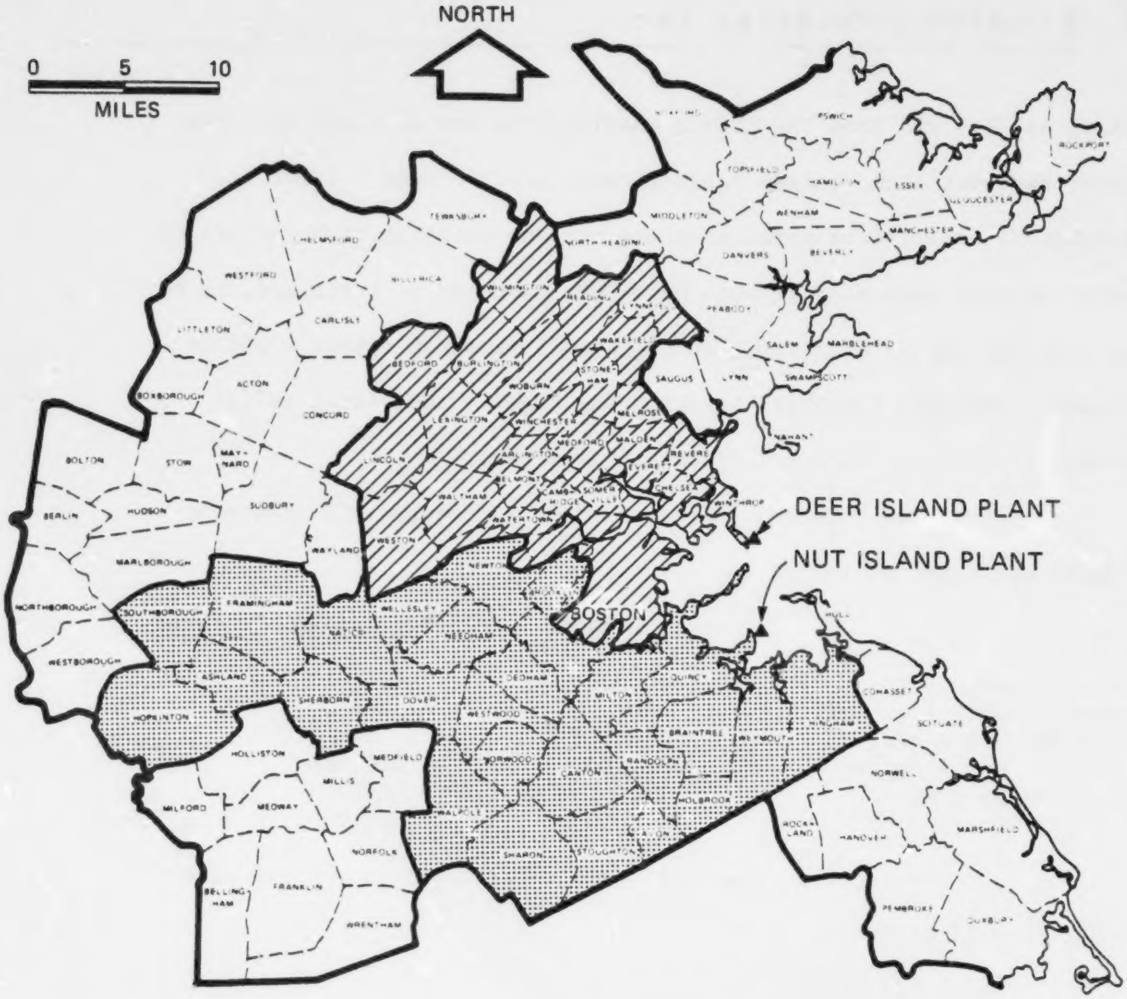
As with all the alternatives for wastewater management presented in this chapter, the EMMA alternatives all assume sludge management to follow the recommendations in the Havens and Emerson report: "A Plan for Sludge Management," and reflected in EMMA Priority Item Nos. 1 and 9. For those alternatives involving satellite treatment plants, the raw sludge in the Category III alternatives would be transported, via MDC raw sewage interceptors to the Nut Island plant for processing. All digested sludge would then be sent to Deer Island for disposal. Where no satellite plants are involved, the extra sludge would still be processed at Nut Island and no transport of raw sludge would be involved. In all cases, the quantities of sludge produced at the various sites were considered in adjusting the costs of Priority Item Nos. 1 and 9.

1. ALTERNATIVE IIIA - CONSOLIDATION OPTION

a. Description and Service Provided

Under Alternative IIIA the two satellite plants would not be built. The same communities in the southern part of the MSD would be served by a single larger capacity plant at (or near) Nut Island as shown on Figure 10-2. The service area tributary to Nut Island in Alternative IIIA may be compared with that of the Recommended Plan shown on Figure 10-1. This alternative is one of the designated options in the EMMA Report and is also in the scope of the Environmental Impact Statement now being prepared.

Pipelines needed to convey raw sewage from the satellite communites would need a capacity of at least the peak hour flow rate,


NORTH
0
5
10
MILES
DEER ISLAND PLANT
NUT ISLAND PLANT
BOSTON
IPSWICH
ROCKPORT
TOPSFIELD
HAMILTON
ESSEX
GLOUCESTER
MIDDLETON
WENHAM
MANCHESTER
TEWKSBURY
NORTH READING
DANVERS
BEVERLY
CHELMSFORD
WESTFORD
BILLERICA
WILMINGTON
READING
LYNNFIELD
PEABODY
CARLISLE
LITTLETON
BEDFORD
BURLINGTON
WAKEFIELD
SALEM
MARBLEHEAD
STONEHAM
SAUGUS
LYNN
SWAMPSCOTT
BOXBOROUGH
ACTON
WOBURN
CONCORD
LEXINGTON
WINCHESTER
MELROSE
NAHANT
MEDFORD
MALDEN
REVERE
BOLTON
STOW
MAYNARD
LINCOLN
ARLINGTON
EVERETT
CHELSEA
BELMONT
CAMBRIDGE
SOMERVILLE
WINTHROP
WALTHAM
BERLIN
HUDSON
SUDBURY
WATERTOWN
WESTON
WAYLAND
MARLBOROUGH
NEWTON
NORTHBOROUGH
SOUTHBOROUGH
FRAMINGHAM
WELLESLEY
BROOKLINE
NATICK
NEEDHAM
HULL
WESTBOROUGH
ASHLAND
DEDHAM
QUINCY
COHASSET
HOPKINTON
SHERBORN
DOVER
WESTWOOD
MILTON
SCITUATE
BRAINTREE
WEYMOUTH
HINGHAM
HOLLISTON
MEDFIELD
MILLIS
NORWOOD
CANTON
RANDOLPH
NORWELL
MILFORD
MEDWAY
WALPOLE
HOLBROOK
ROCKLAND
HANOVER
MARSHFIELD
NORFOLK
SHARON
STOUGHTON
AVON
BELLINGHAM
FRANKLIN
PEMBROKE
DUXBURY
WRENTHAM

LEGEND

▨ DEER ISLAND SERVICE AREA

▩ NUT ISLAND SERVICE AREA

▲ SECONDARY PLANT

NSF Boston Case Study, Phase II Evaluation

CONSOLIDATION OPTION
ALTERNATIVE III A

Kennedy Engineers, Inc. Figure **10·2**
1977

Basemap: EMMA Report

shown as 75.6 mgd from the Middle Charles Area and 67.4 mgd from the Upper Neponset area, unless holding tanks are provided. Since the project alternative is based upon use of some existing trunk sewers on which no peak flow measurements have been reported as performed, it may be that inadequate capacity exists and additional overflows would be caused. Adequate transport capacity may require additional relief sewers or holding tanks and result in more cost.

The influent characteristics to the two MSD treatment plants are expected to be:

	Deer Island	Nut Island	Total
Population	1,460,408	979,910	2,440,318
Average Daily Flow, mgd	400	186.2	586
Influent BOD - mg/l	166	194	-
-lbs/day	555,000	300,000	855,000
Influent SS - mg/l	153	236	-
-lbs/day	511,000	366,000	877,000

Secondary treatment would be provided at the two plants under this alternative.

b. Emissions

Projected quantities of effluent emissions to Boston Harbor and sludge solids produced are:

	Deer Island	Nut Island	Total
Flow, mgd	400	186	586
Effluent BOD, lbs/day	83,200	44,300	127,500
Effluent SS, lbs/day	76,600	45,300	121,900
Sludge Solids Produced, lbs/day	478,000	290,000	768,000

c. Monetary Costs

As for all alternatives in this section, EMMA derived costs were used as much as possible in computing the alternative costs.

The cost of those priority items from the Recommended Plan that are applicable to the alternative were used, either directly or modified, based on flow differences. The costs for new items were derived by ourselves.

The EMMA priority items included in this alternative, as well as our cost adjustments to several items, are presented below. As will be the case for all alternatives in this section, the priority items are grouped by project as was done in Table 3-5 of Chapter 3, and in section D of this Chapter. This allows for cost comparisons in terms of the individual categories considered by EMMA.

	Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1.	Deer Island Sytem (Items 1, 9 expanded. All EMMA items included)	$312.531	$12.551	$231.978
2.	Nut Island System (Items 5, 7 expanded. All EMMA items included)	$180.758	$ 4.517	$122.265
3.	Middle Charles River (Items 10A, 14, 41, 43)	$ 62.941	$ 0.151	$ 35.975
4.	Upper Neponset River (Items 11A, 19, 20, 44, 45)	$ 46.129	$ 0.112	$ 16.381
5.	Combined Sewer Overflows (All EMMA items included)	$270.000	$ 3.900	$175.837
	TOTAL	$872.359	$21.231	$582.436

The following would be the cost responsibility under conditions of 100 percent grant eligibility and assumed reduced (60.25%) eligible, capital cost of $525.6 million. The reduced eligibility assumes that the facilities in Alternative IIIA are built, although the flows quantified in Alternative IC arbitrarily define the eligible sized project.

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
Capital cost	$ 87.2	$399.4
Annual O&M cost	$ 21.2	$ 21.2
State Share		
Capital cost	$130.9	$ 78.8
Federal Share		
Capital cost	$654.3	$394.2
Total		
Capital cost	$872.4	$872.4

d. Benefits

The principal benefit of this alternative is that it eliminates the need for two new AWT plants. Although the same population would be served as in the EMMA Recommended Plan, the elimination of the two river discharges would make AWT unnecessary. This of course eliminates the land use and environmental impacts associated with large-scale construction at the potential plant sites. The fact that AWT will not be employed also reduces the amount of sludge produced, the energy costs associated with treatment, and reduces the degree of sophistication required to maintain and operate the treatment facilities.

An associated benefit is that since smaller plants (i.e. satellite plants) are subject to greater variations in flow, they are more subject to upset caused by biological growth washout. Thus this alternative could result in more stable operation. Should an upset occur at Nut Island, the effect on the receiving waters would be not as serious as at a satellite plant with a river discharge.

2. ALTERNATIVE IIIB, TWO SECONDARY SATELLITE PLANTS

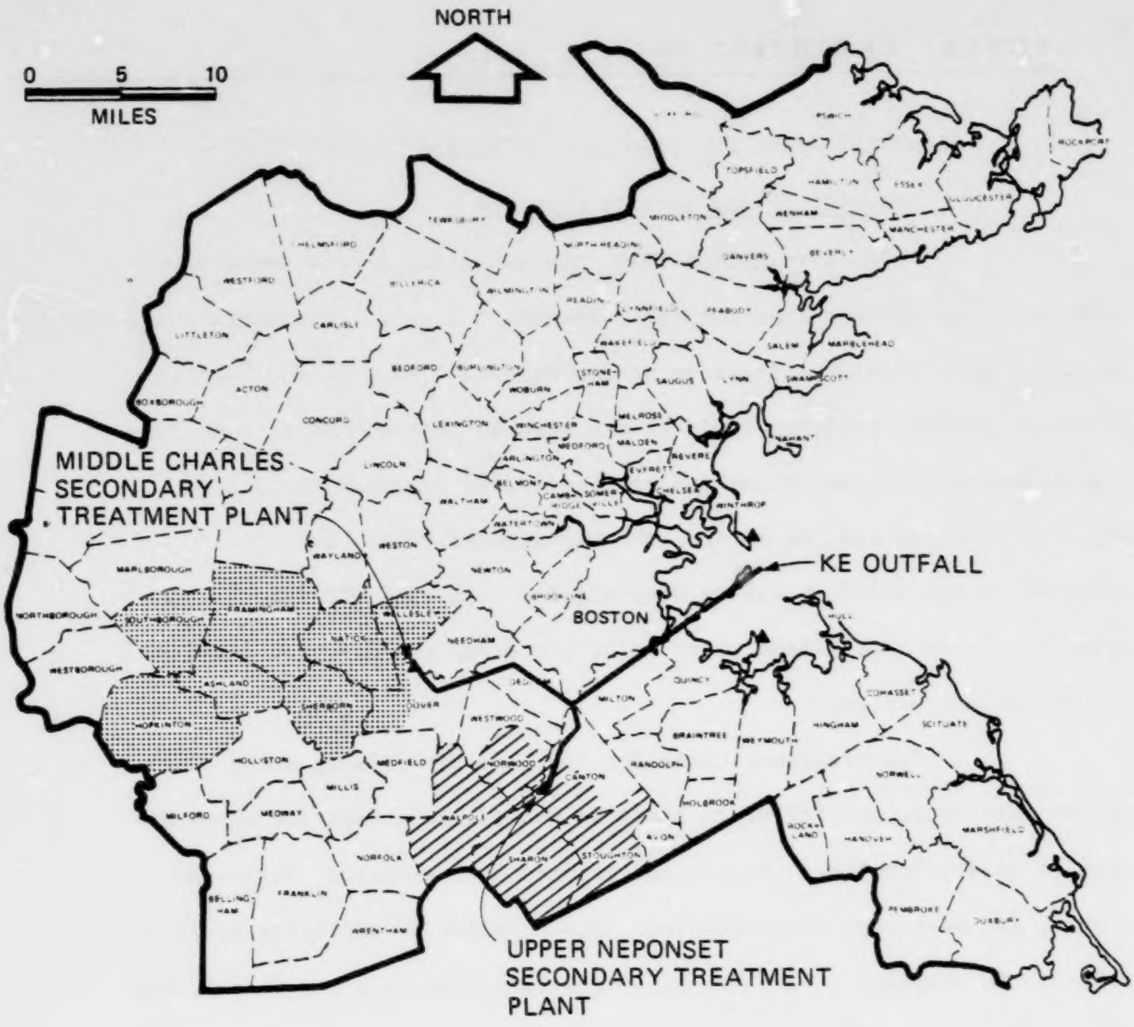
a. Description and Service Provided

Under Alternative IIIB, the satellite plants would provide secondary (rather than tertiary) treatment levels. Effluents would be conveyed to President Roads in Boston Harbor. The size and location of the Nut Island facility would be the same as in the EMMA Recommended Plan. Deer Island facilities and combined sewer overflow facilities would also be the same as in the EMMA Recommended Plan. Satellite treatment plant solids would be discharged to existing MDC interceptors tributary to the Nut Island plant to be processed and disposed of with the Nut Island sludge.*

The treatment train for the satellite plants under Alternative IIIB would be similar to those at Nut Island except for elimination of sludge handling: headworks, primary sedimentation, activated sludge, and secondary sedimentation. Disinfection of effluents would be added to be comparable with Nut Island, although not now required by the EPA regulations. Each plant would also have administrative and maintenance buildings, landscaping and sitework, pumping and flow equalization basins.

Alternative IIIB is shown on Figure 10-3. Following are the influent characteristics expected at the treatment plants.

*(Capacity needed for sludge conveyance would be about one percent of the capacity of existing interceptors. Costs for sludge management are decreased for the satellite plants and increased at the Boston Harbor Plants.)


NORTH
0 5 10
MILES
MIDDLE CHARLES SECONDARY TREATMENT PLANT
KE OUTFALL
BOSTON
UPPER NEPONSET SECONDARY TREATMENT PLANT

LEGEND

▨ UPPER NEPONSET SERVICE AREA

▒ MIDDLE CHARLES SERVICE AREA

▲ SECONDARY PLANT

NSF Boston Case Study, Phase II Evaluation

KENNEDY ENGINEERS PLAN
FOR SATELLITE TREATMENT PLANTS
ALTERNATIVE III B

Kennedy Engineers, Inc. 1977

Figure **10·3**

Basemap: EMMA Report

	Deer Island	Nut Island	Middle Charles	Upper Neponset
Population	1,460,408	674,910	181,000	124,000
Avg. Daily Flow, mgd	400	130	31	25.2
Influent BOD - mg/l	166	185	222	200
-lbs/day	555,000	201,000	57,400	42,000
Influent SS - mg/l	153	259	183	178
-lbs/day	511,000	281,000	47,400	37,500
Influent NH_3-N - mg/l	---	---	21.0	20.9
-lbs/day	---	---	5,430	4,400
Influent Total P - mg/l	---	---	12.0	12.4
-lbs/day	---	---	3,100	2,600

As explained earlier, the EMMA Recommended Plan calls for Advanced Waste Treatment at the two satellite plants with discharges to augment the flow in the Neponset and Charles Rivers. A viable alternative to consider is the provision of only secondary treatment at the two plants, and the construction of a force main from the plants to Boston Harbor. Discharge of the secondary effluent would then occur in the vicinity of the President Roads where tidal action would provide diffusion and dilution in salt water.

In laying out a preliminary alignment for the force main (Figure 10-3), a route was selected to minimize the amount of pumping that would be necessary. It was also routed to minimize the length of force main that would pass through heavily congested, and environmentally sensitive areas.

An equalization basin would be used at each plant prior to the effluent pumping station to allow use of a smaller force main. The basins would have the effect of smoothing out the diurnal fluctuations that occur. The force main would carry a relatively constant flow, with reduced peaks. Thus the outfall could be sized for a flow only ten percent greater than the average daily flow given in the EMMA Study for the satellite treatment plants (25.2 mgd for the Upper

Neponset plant and 31.0 mgd for the Middle Charles plant).

b. Emissions

The following emissions to Boston Harbor are to be expected. Also given are the quantities of anticipated sludge production.

	Deer Island	Nut Island	Middle Charles	Upper Neponset	B.H. Outfall from Satellite Plants
Flow, mgd	400	130	---	---	56
BOD, lbs/day	83,200	30,200	---	---	14,100
SS, lbs/day	76,600	32,600	---	---	12,700
NH_3-N, lbs/day	--	--	---	---	6,880
Total P, lbs/day	--	--	---	---	4,000
Sludge Solids Produced -lbs/day	478,000	210,000	44,000	36,000	---

c. Monetary Costs

The estimated costs for alternative IIIB follow:

Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1. Deer Island System (All EMMA items)	$302.553	$12.351	$224.317
2. Nut Island System (All EMMA items)	$147.736	$ 4.107	$101.886
3. Middle Charles River (EMMA items 14, 41 43 and new items)	$ 58.361	$ 1.118	$ 37.799
4. Upper Neponset River (EMMA items 19, 20, 44, 45 and new items)	$ 38.919	$ 0.955	$ 27.290
5. Combined Sewer Overflows (All EMMA items)	$270.000	$ 3.900	$175.837
6. New items	$ 24.970	$ 0.320	$ 14.107
Total	$842.539	$22.751	$581.236

The new items in group 6 above include an outfall from the satellite plants to Boston Harbor, the incremental cost of sludge processing at Deer and Nut Islands, and the following to be provided at both satellite plants:

(1) force main
(2) effluent pumping
(3) flow equalization
(4) secondary treatment.

The anticipated cost breakdown under conditions of full and reduced grant eligibility would be:

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
Capital cost	$ 84.3	$385.7
Annual O&M cost	$ 22.7	$ 22.7
State Share		
Capital cost	$126.4	$ 76.1
Federal Share		
Capital cost	$631.8	$380.7
Total		
Capital cost	$842.5	$842.5

d. Benefits

In comparison with the EMMA Recommended Plans, the chief benefits of this proposal are simplified operation, lower operating costs and elimination of all the treatment plant effluent from the rivers, including toxic substances that might escape removal in the AWT treatment proposed. Less land is required for a secondary plant than for a tertiary plant, and less sludge is produced.

The feature of conveyance of solids through MDC interceptors to the Nut Island treatment plant would eliminate the need for local sludge processing and disposal facilities. It also eliminates nuisance problems, by using procedures similar to those used at Cottage where screening and sludge are sent to Deer Island via MDC interceptors.

When compared with those alternatives that do not include satellite plants, other benefits are seen. One is that the satellite plants can be built in sparsely populated areas where environmental impacts, both during and after construction, can be minimized. Without the satellite plants, expansion of the Nut Island Plant would be necessary. This would require either harbor fill at Nut Island, or the acquisition of another larger site in the Boston Harbor area.

Another benefit is the relative ease of future expansion of the satellite plants, should this become necessary. This is to be contrasted with the restricted space available near Nut Island.

3. ALTERNATIVE IIIC, TWO SECONDARY SATELLITE PLANTS

a. Description and Service Provided

This alternative is similar to IIIB except that the satellite plants would discharge to the rivers instead of to an outfall that conveys the effluent to Boston Harbor. As before, the satellite plants would provide secondary treatment, and the size and location of the Nut Island Plant is to be the same as in EMMA.

The description of the satellite plants is identical to that under Alternative IIIB. The influent loadings and population served are also identical to Alternative IIIB.

b. Emissions

The expected emissions from the four MDC treatment plants follow. It should be noted that Deer and Nut Island discharge to the Harbor, but the satellite plants discharge to the respective rivers.

	Deer Island	Nut Island	Middle Charles	Upper Neponset
Flow, mgd	400	130	31	25.2
BOD, lbs/day	83,200	30,200	7,800	6,300
SS, lbs/day	76,600	32,600	7,100	5,600
NH_3-N, lbs/day	--	--	3,800	3,080
Total P, lbs/day	--	--	2,170	1,820
Sludge Solids Produced, lbs/day	478,000	210,000	44,000	36,000

c. Monetary Costs

The alternative costs follow:

	Group	Capital Costs (million)	Annual O&M (million)	Present Worth (million)
1.	Deer Island System (All EMMA items)	$302.553	$12.351	$224.317
2.	Nut Island System (All EMMA items)	$147.736	$ 4.107	$101.886
3.	Middle Charles River (EMMA items 14, 41, 43 and new items)	$ 52.241	$ 0.998	$ 33.474
4.	Upper Neponset River (EMMA items 19, 20, 44, 45 and new items)	$ 34.199	$ 0.864	$ 24.023
5.	Combined Sewer Overflows (All EMMA items)	$270.000	$ 3.900	$175.837
6.	Other new items.	$ 3.220	$ 0.320	$ 3.465
	Total	$809.949	$22.540	$563.002

The new items include incremental costs for consolidated sludge processing at Deer and Nut Islands, and the following at each satellite plant:

(1) secondary treatment
(2) effluent line to the river.

The cost responsibility divides up as follows:

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
Capital cost	$ 81.0	$370.8
Annual O&M cost	$ 22.5	$ 22.5
State Share		
Capital cost	$121.5	$ 73.2
Federal Share		
Capital cost	$607.5	$366.0
Total		
Capital cost	$810.0	$810.0

d. Benefits

The chief benefits of Alternative IIIC include the maintenance of waters within the basin and the provision of flow augmentation in the rivers. It must be realized that maintenance of water in its basin of origination is only important for those communities that do not import water. Other communities already violate the principle by the transportation of water between basins through such districts as the MSD. Low flow augmentation is important to prevent river stagnation, and to improve dilution and flushing.

Another advantage of this alternative over those without river discharges is elimination of the need to construct long outfalls. In addition to the expense involved, the laying of these pipelines can cause temporary ecological upset, although such impacts can be minimized through route selection.

Other benefits were discussed under Alternative IIIB, and include: simplified operation, lower operating costs, less land requirements, ease of expansion, and reduction in sludge production.

4. ALTERNATIVE IIID, TWO LAND SATELLITE PLANTS

a. Description and Service Provided

Alternative IIID, would include two satellite land treatment plants with land disposal. The Service Areas, and capacities of the satellite plants, would be the same as in the EMMA Recommended Plan. Provision is made for the land treatment plants to be anywhere within a 20-mile radius of the plants in Alternative IIIC. The Deer and Nut Island Plants would be identical to the proposals in EMMA.

Treatment at the satellite plants would consist of waste stabilization through the use of aerated lagoons and chlorination. Storage for 4 to 5 months would be provided. A force main and pump station would be provided to convey the effluent to the disposal site. Land application would be by means of Center Pivot Irrigation with underdrains and with open channel return flow lines provided. The return flow is estimated to be approximately one-half of the plant influent flow, and would be discharged to the Neponset or Charles Rivers at approximately the same locations as in Alternative IIIC. The irrigation is expected to produce a marketable crop which would aid in cost-recovery of the system.

The influent characteristics would be identical to those of Alternatives IIIB, IIIC and the EMMA Plan.

b. Emissions

The two harbor treatment plants would discharge to Boston Harbor as in the previous two alternatives. Flow would be stored at the two satellite plants during the winter and would discharge the irrigation return flow to the rivers during the warmer periods to augment river flows. Discharges for the satellite areas shown below are estimated average annual amounts with the balance disposed of by evapotranspiration and percolation.

	Deer Island	Nut Island	Middle Charles	Upper Neponset
Flow, mgd	400	130	16	13
BOD, lbs/day	83,200	30,200	390	310
SS, lbs/day	76,600	32,600	900	730
NH_3-N, lbs/day	--	--	80	60
Total P, lbs/day	--	--	10	10
Sludge Solids Produced, lbs/day	478,000	210,000	0	0

c. Monetary Costs

The new cost components are pumping conveyance, treatment and land disposal at each of the two satellite areas. Accordingly, the estimated costs are:

	Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1.	Deer Island System (All EMMA items)	$302.553	$12.351	$224.317
2.	Nut Island System (All EMMA items)	$147.736	$ 4.107	$101.886
3.	Middle Charles River (EMMA items 14, 41 43 and new items)	$ 71.601	$ 1.154	$ 43.516
4.	Upper Neponset River (EMMA items 19, 20, 44, 45 and new items)	$ 50.409	$ 0.921	$ 30.559
5.	Combined Sewer Overflows (All EMMA items)	$270.000	$ 3.900	$175.837
6.	Other items	0	0	0
	Total	$842.299	$22.433	$576.115

NOTE: New cost items include an allowance for the land assumed to be grant eligible equal to 144 acres per million gallons irrigated of the total needed of 227 acres per million gallons treated by land disposed (63.4%).

The following cost breakdown applies to alternative IIIE:

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
Capital cost	$ 84.2	$385.6
Annual O&M cost	$ 22.4	$ 22.4
State Share		
Capital cost	$126.3	$ 76.1
Federal Share		
Capital cost	$631.7	$380.6
Total		
Capital cost	$842.3	$842.3

d. Benefits

A major benefit of Alternative IIID is the simplicity of operation of the satellite plants. The maintenance level is relatively low, although this is somewhat compensated for by the maintenance required at the irrigation site. The stability of a lagoon system is relatively high, thus minimizing the chances of upset. Energy use in such a system is quite low.

Since the return flow is to be discharged to the rivers, the same advantages of flow augmentation apply as with Alternative IIIC.

A very important benefit is the absence of sludge production. Sludge handling is a major expense, and often a headache at treatment plants, so an alternative that does not require sludge h has an advantage in this regard.

5. ALTERNATIVE IIIE, ONE SECONDARY SATELLITE PLANT

a. Description and Service Provided

This alternative is essentially the same as Alternative IIIB, but with a single satellite plant serving both watersheds.

The new satellite plant would be located at a site at the mid-part of the Neponset River. Both harbor plants would remain as described in EMMA.

The service area and population served by the Middle Neponset Plant would be a combination of the service areas and populations of the EMMA satellite plants. It would be a secondary plant, with a treatment train consisting of headworks, primary sedimentation, activated sludge, secondary sedimentation and disinfection. The satellite plant would also include an equalization basin as with Alternative IIIB.

Disposal of the effluent would be to President Roads in Boston Harbor. Consequently effluent pumping, an outfall and diffuser would be provided. Because the new plant would serve the same area as the two EMMA proposed satellite plants, additional raw sewage interceptors would be necessary to convey the sewage to the site of the new plant. These interceptors must be able to transport peak flows of 75.6 mgd from the Middle Charles and 67.4 mgd from the Upper Neponset site.

The influent characteristics of the Middle Neponset River Treatment Plant follow. The influents to the Harbor plants are identical to those described in Alternative IIIB.

	Middle Neponset River
Population	305,000
Flow, mgd	56.2
BOD - mg/l	212
-lbs/day	99,400
SS -mg/l	181
- lbs/day	84,900
NH_3-N - mg/l	21.0
- lbs/day	9,830
Total P - mg/l	12.2
- lbs/day	5,700

b. Emissions

The emissions to Boston Harbor from the Middle Neponset Plant follow. Those from the Harbor Plants are identical to Alternative IIIB.

	Middle Neponset River
Flow, mgd	56
BOD, lbs/day	14,100
SS, lbs/day	12,700
NH_3-N, lbs/day	6,880
Total P, lbs/day	4,000
Sludge Solids Produced, lbs/day	80,000

c. Monetary Costs

The estimated costs for Alternative IIIE are given below:

	Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1.	Deer Island System (All EMMA items)	$302.553	$12.351	$224.317
2.	Nut Island System (All EMMA items)	$147.736	$ 4.107	$101.886
3.	Middle Charles River (EMMA items 14, 41, 43 and new items)	$ 38.267	$ 0.154	$ 21.801
4.	Upper Neponset River (EMMA items 19, 20, 44, 45 and new items)	$ 21.419	$ 0.105	$ 10.948
5.	Combined Sewer Overflows (all EMMA items)	$270.000	$ 3.900	$175.837
6.	Other items	$ 63.182	$ 1.645	$ 41.002
	Total	$843.157	$22.262	$575.791

The new items include an incremental cost for sludge processing at Deer and Nut Islands an outfall to Boston Harbor from the satellite plants, secondary treatment for 56.2 mgd at the Middle Neponset River site, flow equalization for 62 mgd and effluent pumping at the site, and the following items at both the Middle Charles and Upper

Neponset sites:
(1) pump station
(2) raw sewage interceptor

Following is the cost responsibility:

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
Capital cost	$ 84.3	$386.0
Annual O&M cost	$ 22.3	$ 22.3
State Share		
Capital cost	$126.5	$ 76.2
Federal Share		
Capital cost	$632.4	$381.0
Total -		
Capital cost	$843.2	$843.2

d. Benefits

The major benefits of this plan relate to the advantages of constructing one satellite plant instead of two as EMMA recommends, and elimination of AWT and sludge processing. The benefit of the cost saving in construction may be achieved from economies of scale. This term was defined earlier as the decrease in incremental construction cost as the capacity of the treatment plant increases.

Less land is required for the one satellite plant than two, although the construction of additional interceptors is required. As mentioned earlier, larger plants are less succeptible to upsetting, so plant reliability is increased in this alternative. Should an upset occur, the discharge would be to the Harbor where more dilution is available than in the rivers.

The advantages of the satellite plant providing only secondary treatment were discussed earlier and include energy savings and ease of operation and maintenance.

6. ALTERNATIVE IIIF, ONE SECONDARY SATELLITE PLANT

a. Description and Service Provided

Alternative IIIF is similar to IIIE except that the discharge is to the Neponset River rather than to Boston Harbor. The description of the facility is the same as for Alternative IIIE except that the equalization basin, effluent pumping, and the harbor outfall would not be necessary.

The influent to the Middle Neponset Plant has the same characteristics as described under the previous alternative. The Harbor Plants' influent can be found under Alternative IIIB.

b. Emissions

Because identical treatment would be provided, expected emissions are the same as for Alternative IIIE. The location of the discharge from the satellite plant would be to the Middle Neponset River above the Mother Brook rather than to Boston Harbor.

c. Monetary Costs

The costs developed for this alternative include a secondary treatment for 56.2 mgd at the Middle Neponset River site, a 78" outfall to the Neponset River, an incremental cost for sludge processing at the Harbor plants, and the following facilities at the Middle Charles and Upper Neponset River sites:

(1) pump station
(2) raw sewage interceptor

The following costs apply:

	Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1.	Deer Island System (All EMMA items)	$302.553	$12.351	$224.317
2.	Nut Island System (All EMMA items)	$147.736	$ 4.107	$101.886
3.	Middle Charles River (EMMA items 14, 41, 43 and new items)	$ 38.267	$ 0.154	$ 21.801
4.	Upper Neponset River (EMMA items 19, 20, 44, 45 and new items)	$ 21.419	$ 0.105	$ 10.948
5.	Combined Sewer Overflows (All EMMA items)	$270.000	$ 3.900	$175.837
6.	Other Items	$ 39.950	$ 1.600	$ 29.324
	Total	$819.925	$22.217	$564.113

The new items in groups 3 and 4 are raw sewage pump stations and interceptors for conveyance to a new plant site to serve all satellite communities.

The other new items in group 6 above consist of a 56 mgd secondary treatment plant on the Middle Neponset River, an outfall to the river, and costs for consolidated sludge processing with Nut Island sludge.

The capital cost responsibility follows:

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
Capital cost	$ 82.0	$375.3
Annual O&M cost	$ 22.2	$ 22.2
State Share		
Capital cost	$123.0	$ 74.1
Federal Share		
Capital cost	$614.9	$370.5
Total -		
Capital cost	$819.9	$819.9

d. Benefits

In addition to those benefits discussed earlier with regard to a single satellite plant, this alternative also provides the advantages of flow augmentation in the Neponset River, and elimination of construction of the long outfall to the Harbor.

7. ALTERNATIVE IIIG, ONE LAND SATELLITE PLANT

a. Description and Service Provided

This alternative includes a single land treatment plant to serve all satellite communities. The plant would provide the same treatment as the two plants in Alternative IIID. The return flow from irrigation would be discharged to the Middle Neponset River above Mother Brook.

As in Alternatives IIIE and IIIF, pump stations and force mains would be provided to convey the flow from the satellite communities to the irrigation site. The population, service area and influent characteristics for all plants are the same as for Alternative IIIE.

b. Emissions

The discharges from Deer and Nut Islands are the same as Alternative IIIB. The Middle Neponset Plant would seasonally discharge the return flow to the Middle Neponset River in a manner as described in Alternative IIID.

	Middle Neponset River
Flow, mgd	28
BOD, lbs/day	700
SS, lbs/day	1,600
NH_3-N, lbs/day	140
Total P, lbs/day	10
Sludge Solids Produced, lbs/day	0

c. Monetary costs

The cost of Alternative IIIG has been estimated with the following new items:

(1) Pump stations and force mains at the Middle Charles River and Upper Neponset River satellite areas,

(2) A land treatment facility (located approximately twenty miles away) with a capacity of 56.2 mgd and return flow conveyance to the Middle Neponset River.

Estimated costs of this alternative are:

	Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1.	Deer Island System (All EMMA items)	$302.553	$12.351	$224.317
2.	Nut Island System (All EMMA items)	$147.736	$ 4.107	$101.886
3.	Middle Charles River (EMMA items 14, 41, 43 and new items)	$ 38.267	$ 0.154	$ 21.801
4.	Upper Neponset River (EMMA items 19, 20, 44, 45 and new items)	$ 21.419	$ 0.105	$ 10.948
5.	Combined Sewer Overflows (All EMMA items)	$270.000	$ 3.900	$175.837
6.	Other items	$ 73.430	$ 1.801	$ 47.886
	Total	$853.405	$22.418	$582.675

The new costs items in groups 3 and 4 are for pump stations and force mains to convey raw sewage to a common site. The new costs items in group 6 are for land treatment facilities to serve the satellite communites.

For this alternative, the cost breakdown would be:

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
capital cost	$ 85.3	$390.6
Annual O&M cost	$ 22.4	$ 22.4
State Share		
capital cost	$128.0	$ 77.1
Federal Share		
capital cost	$640.1	$385.7
Total -		
capital cost	$853.4	$853.4

d. Benefits

The benefits of a land application system are discussed under Alternative IIID. Other advantages of a one-satellite plant alternative with a river discharge are mentioned under the two previous alternatives.

8. ALTERNATIVE IIIH, ONE AWT SATELLITE PLANT

a. Description and Service Provided

This system is essentially the same as Alternative IIIF with the exception that advanced waste treatment would be provided at the Middle Neponset River Plant.. Costs are based on a treatment train at the plant similar to that described in the EMMA Recommended Plan for the satellite plants: primary sedimentation, activated sludge, secondary sedimentation, nitrification with settling, multi-media filtration and chlorination. Sludge solids would be conveyed to Nut Island for consolidated processing.

As with Alternative IIIE, pump stations and force mains would be provided to convey the raw sewage to the satellite plant. The alternative is based on the same populations, service areas and influent characteristics of all plants as in Alternative IIIE. Discharge from the plant would be to the Middle Neponset River above Mother Brook.

b. Emissions

The expected discharge to the Neponset River follows. Emissions from the Harbor plants would be the same as in Alternative IIIB.

	Middle Neponset River
Flow, mgd	56
BOD, lbs/day	2,300
SS, lbs/day	2,300
NH_3-N, lbs/day	470
Total P, lbs/day	470
Sludge Solids Produced, lbs/day	130,000

c. Monetary costs

Following are the costs for Alternative IIIH.

	Group	Capital Costs (million)	Annual O&M (million)	Present Worth (million)
1.	Deer Island System (All EMMA items)	$302.553	$12.351	$224.317
2.	Nut Island System (All EMMA items)	$147.736	$ 4.107	$101.886
3.	Middle Charles River (EMMA items 14, 41, 43 and new items)	$ 38.267	$ 0.154	$ 21.801
4.	Upper Neponset River (EMMA items 19, 20, 44, 45 and new items)	$ 21.419	$ 0.105	$ 10.948
5.	Combined Sewer Overflows (All EMMA items)	$270.000	$ 3.900	$175.837
6.	Other items	$ 75.530	$ 4.010	$ 62.849
	Total	$855.505	$24.627	$597.638

The new items for which we have estimated costs in group 6 are an advanced waste treatment facility for handling 56.2 mgd at the Middle Neponset River site, a 78" outfall from the plant to the Neponset River, and an incremental cost for additional sludge processing facilities at the two Harbor plants. Included in groups 3 and 4 are a pump station and raw sewage interceptor at both the Middle Charles River and Upper Neponset River sites.

The responsibility for the capital costs would be defined as follows:

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
capital cost	$ 85.6	$391.6
Annual O&M cost	$ 24.6	$ 24.6
State Share		
capital cost	$128.3	$ 77.3
Federal Share		
capital cost	$641.6	$386.6
Total -		
capital cost	$855.5	$855.5

d. Benefits

In addition to the benefits of a single satellite plant with a river discharge discussed earlier, this alternative has the feature of discharging advanced treated effluent to the Neponset River. Advanced treatment is expected to remove an additional 25 mg/1 of BOD and suspended solids, as well as virtually all the ammonia nitrogen and total phosphorous from the waste. This reduces the organic and nutrient loading on the river thus reducing the possibility of such effluent-induced ecological effects as algal growths and depressed dissolved oxygen levels.

9. ALTERNATIVE IIIJ, OCEAN DISPOSAL OPTION

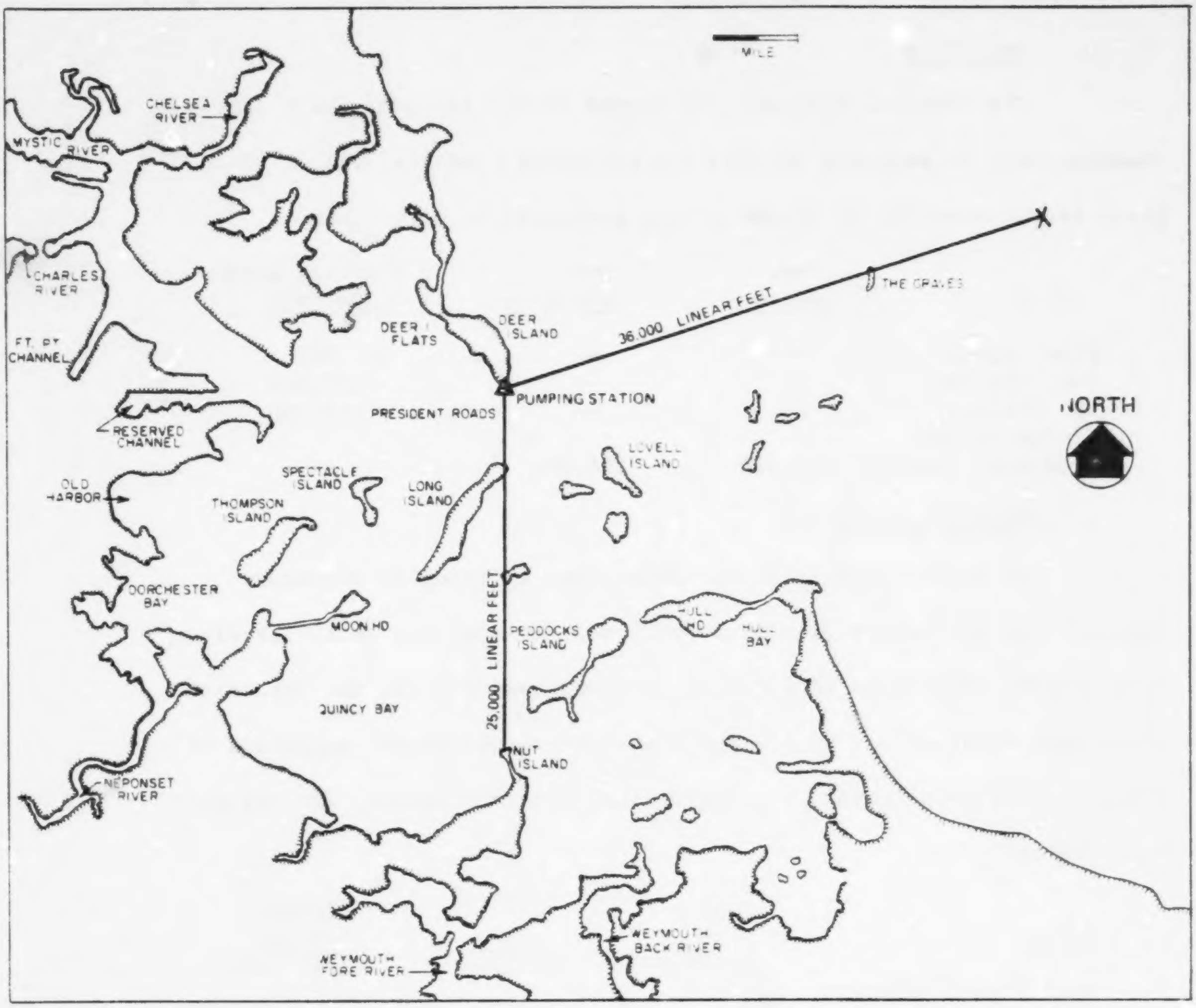
a. Description and Services Provided

In Alternative IIIJ, the service areas and all facilities would be the same as in Alternative IIIA except that the two plants, Deer Island and Nut Island, would provide only primary treatment levels. Under this alternative to IIIA, the combined effluents would be diffused at 100-foot depth in Massachusetts Bay beyond the The Graves Islands, seven miles from Deer Island, as shown on Figure 10-4. This alternative is one of the OPTIONS designated in the EMMA Report. It is not being considered in the Environmental Impact Statement, however, because it would not comply with requirements of Public Law 92-500.

The ocean discharge, in lieu of secondary treatment, basically consists of deleting from the Recommended Plan the secondary treatment extension and secondary sludge management of the Deer and Nut Island facilities and discharging primary effluent, via submarine outfall extension, in deep ocean water beyond the Graves. The process is referred to as Marine secondary treatment. Also included in this option would be expansion of the Deer Island facilities effluent pumping station to include capacity for the Nut Island primary effluent. In this option only primary treatment is provided at the Nut and Deer facilities prior to discharge.

The service areas, populations and influent characteristics to this can be found under Alternative IIIA.

The consideration of primary treatment and a deep ocean outfall as equivalent to secondary treatment would require a waiver of present regulations.


MILE
CHELSEA RIVER
MYSTIC RIVER
CHARLES RIVER
FT. PT CHANNEL
DEER I FLATS
DEER ISLAND
36,000 LINEAR FEET
THE GRAVES
PUMPING STATION
PRESIDENT ROADS
NORTH
RESERVED CHANNEL
OLD HARBOR
SPECTACLE ISLAND
LONG ISLAND
LOVELL ISLAND
THOMPSON ISLAND
DORCHESTER BAY
MOON HD
25,000 LINEAR FEET
PEDDOCKS ISLAND
HULL HD
HULL BAY
QUINCY BAY
NUT ISLAND
NEPONSET RIVER
WEYMOUTH BACK RIVER
WEYMOUTH FORE RIVER

OCEAN OUTFALL DISCHARGE PLAN

Source: EMMA MAIN REPORT, page 7-5

NSF Boston Case Study, Phase II Evaluation

OCEAN DISPOSAL OPTION
ALTERNATIVE III J

Kennedy Engineers, Inc. 1977

Figure **10·4**

b. Emissions

The combined effluent discharged to the Atlantic Ocean (Massachusetts Bay) is expected to have the following characteristics. Also given is the quantity of sludge solids generated at each plant.

	Deer Island	Nut Island	Combined Ocean Outfall
Flow, mgd	--	--	586
BOD, lbs/day	--	--	555,000
SS, lbs/day	--	--	413,000
Sludge Solids Produced, lbs/day	266,000	198,000	---

c. Monetary Costs

In this alternative, all EMMA items relating to secondary treatment at the Harbor Plants are excluded, in addition to all satellite plants. New items included in the cost estimate are the expansion of primary treatment at Nut Island due to increased flows, expansion of primary sludge management, pumping of the primary effluent, and the deep ocean outfall.

	Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1.	Deer Island System (All EMMA items except Nos. 8 & 9. Expansion of No. 1)	$129.215	$ 8.500	$107.819
2.	Nut Island System (All EMMA items except No. 7. Expansion of No. 5)	$ 73.194	$ 2.775	$ 54.901
3.	Middle Charles River (EMMA items 14, 41, 43 & 10A)	$ 62.941	$ 0.151	$ 35.975
4.	Upper Neponset River (EMMA items 19, 20, 44, 45 & 11A)	$ 46.129	$ 0.112	$ 16.381
5.	Combined Sewer Overflows (all EMMA items)	$270.000	$ 3.900	$175.837
6.	Other items	$156.367	$ 1.761	$ 84.832
	Total	$737.846	$17.199	$475.745

Below is the cost responsibility:

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
Capital cost	$ 73.8	$337.7
Annual O&M cost	$ 17.2	$ 17.2
State Share capital cost	$110.7	$ 66.7
Federal Share capital cost	$553.4	$333.4
Total - capital cost	$737.8	$737.8

d. Benefits

It is emphasized that neither this alternative, nor IIIK, satisfies the requirement of secondary treatment in the Act, however, there are advantages that must be considered.

One benefit of this alternative is the simplicity and lower cost of operation and maintenance of primary plants. Since the level of sophistication of such system is low, and no biological treatment is involved, consistency of treatment is virtually assured.

Since only primary treatment would be employed at Harbor plants, less land would be required at Deer and Nut Islands, thus reducing (or eliminating) the need for bay fill. Also, less sludge would be produced, so digestion facilities would be smaller, and the energy requirement would be less. Other benefits of eliminating the EMMA proposed satellite plants were discussed under alternative IIIA.

This alternative has the unique benefit of disposing of the effluent in the ocean where great dilution is available. Although only primary treatment is afforded, the ocean's tremendous assimilation capacity along with the cost savings make this alternative attractive.

10. ALTERNATIVE IIIK, PRIMARY TREATMENT

a. Description and Service Provided

Alternative IIIK is similar to Alternative IIIJ except that the two primary Harbor plants would separately discharge into the Harbor at the same locations as at present.* The influent characteristics are the same as under Alternative IIIA.

b. Emissions

The discharges in the Harbor are projected to have the following characteristics:

	Deer Island	Nut Island	Total
Flow, mgd	400	186	586
BOD, lbs/day	339,000	216,000	555,000
SS, lbs/day	245,000	168,000	413,000
Sludge Solids Produced, lbs/day	266,000	198,000	464,000

c. Monetary Cost

The costs for Alternative IIIK are similar to those of the previous Alternative except that no costs are included for effluent pumping and a deep ocean outfall.

*(It is noted that a research study and modeling of Boston Harbor sponsored by DWPC in 1974 showed that primary treatment facilities did not have an adverse effect on Harbor water quality, and that DWPC has long been publicly against secondary treatment at these plants.)

	Group	Capital Cost (million)	Annual O&M (million)	Present Worth (million)
1.	Deer Island System (All EMMA items except Nos. 8 & 9. Expansion of No. 1)	$129.215	$ 8.500	$107.819
2.	Nut Island System (All EMMA items except No. 7. Expansion of No. 5.	$ 73.194	$ 2.775	$ 54.901
3.	Middle Charles River (EMMA items 14, 41, 43 & 10A)	$ 62.941	$ 0.151	$ 35.975
4.	Upper Neponset River (EMMA items 19, 20, 44 45 & 11A)	$ 46.129	$ 0.112	$ 16.381
5.	Combined Sewer Overflows (All EMMA items)	$270.000	$ 3.900	$175.837
6.	Other items	0	0	0
	Total	$581.479	$15.438	$390.913

Following is how the responsibility for the capital cost divides up:

	100% Eligibility (million)	60.25% Reduced Eligibility (million)
Local Share		
Capital cost	$ 58.2	$266.1
Annual O&M cost	$ 15.4	$ 15.4
State Share		
Capital cost	$ 87.2	$ 52.6
Federal Share		
Capital cost	$436.1	$262.8
Total -		
Capital cost	$581.5	$581.5

d. Benefits

The principal advantage of Alternative IIIK is the cost saving. Savings over the EMMA plan are achieved through eliminating the satellite plants and providing only primary treatment at Deer and Nut Island. Savings over the previous alternative are created by eliminating the deep ocean outfall.

F. COMPARISON OF ALTERNATIVES

In order to allow for effective comparisons of the many alternatives presented in this chapter, we include several summary tables and figures.

Figure 10-5 diagramatically displays the services provided under the various alternatives. Displayed are the number and location of treatment plants, conveyance routes, location of discharges, and the level of treatment provided at each plant. The average daily flow is given for each discharge and each is numbered to allow the reader to characterize the emission by referring to Table 10-3.

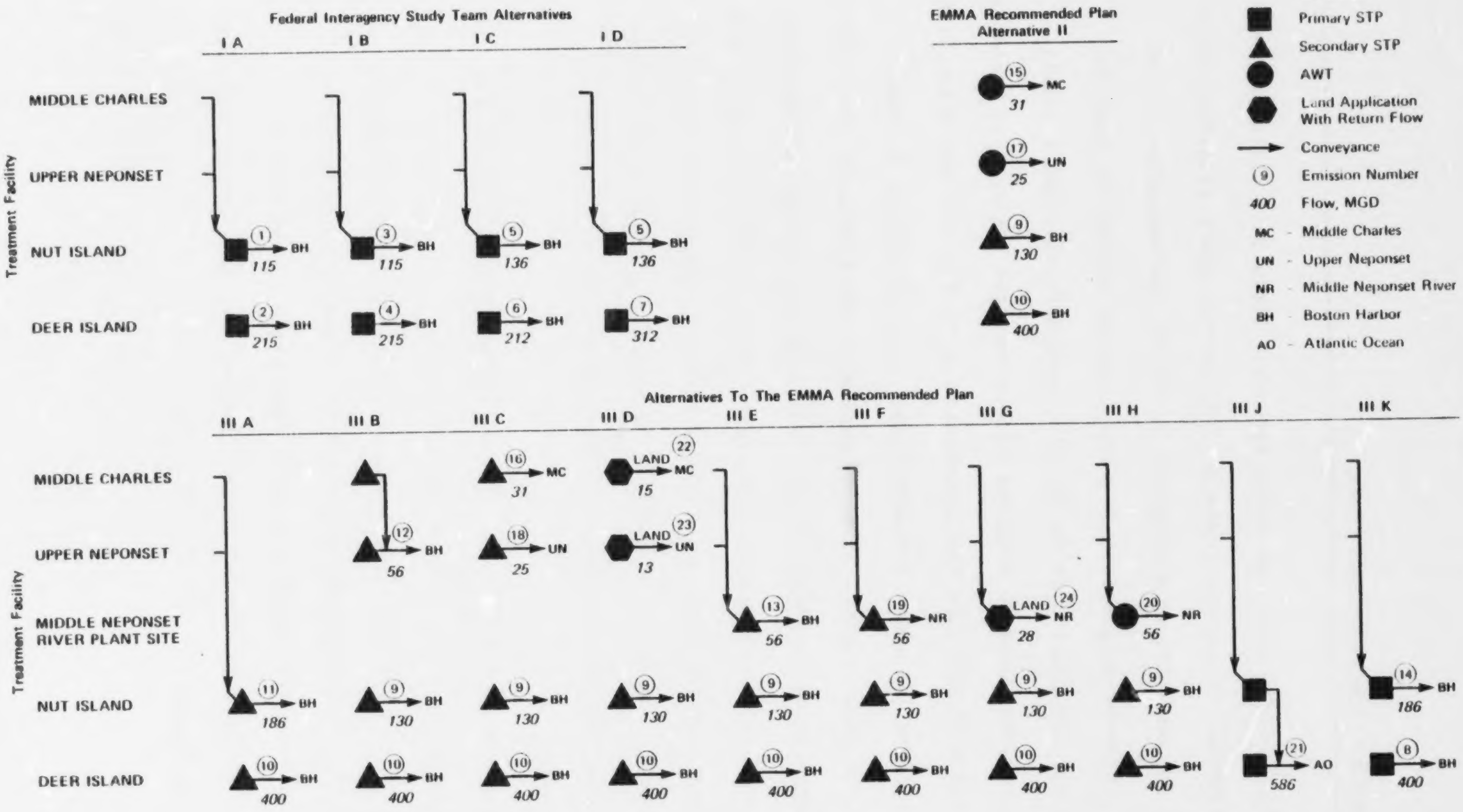
Table 10-2 gives the population that would be served and lists the quantity and nature of the influent to each treatment facility for each alternative.

Table 10-3 indicates the character of each emission identified in Figure 10-5. The emissions are grouped by location of discharge.

Table 10-4 presents the quantities of sludge produced at each of the treatment plants under the alternatives.

The alternatives in categories I and II are based on sludge management as described in the EMMA Report: separate sludge facilities at each satellite plant, where applicable, and disposal of Nut Island sludge at Deer Island. In the category III alternatives, sludge generated at secondary or AWT satellite plants would be processed at Nut Island.

Tables 10-5, 10-6 and 10-7 summarize the costs of the alternatives. Table 10-5 lists each alternative with the capital cost, annual operation and maintenance cost and present worth. Tables 10-6 and 10-7 present the responsibilities for the capital costs divided between the


Federal Interagency Study Team Alternatives
I A
I B
I C
I D
EMMA Recommended Plan Alternative II
LEGEND
■ Primary STP
▲ Secondary STP
● AWT
⬢ Land Application With Return Flow
→ Conveyance
⑨ Emission Number
400 Flow, MGD
MC - Middle Charles
UN - Upper Neponset
NR - Middle Neponset River
BH - Boston Harbor
AO - Atlantic Ocean
Treatment Facility
MIDDLE CHARLES
UPPER NEPONSET
NUT ISLAND
DEER ISLAND
① 115 BH
② 215 BH
③ 115 BH
④ 215 BH
⑤ 136 BH
⑥ 212 BH
⑤ 136 BH
⑦ 312 BH
⑮ 31 MC
⑰ 25 UN
⑨ 130 BH
⑩ 400 BH
Alternatives To The EMMA Recommended Plan
III A
III B
III C
III D
III E
III F
III G
III H
III J
III K
Treatment Facility
MIDDLE CHARLES
UPPER NEPONSET
MIDDLE NEPONSET RIVER PLANT SITE
NUT ISLAND
DEER ISLAND
⑪ 186 BH
⑩ 400 BH
⑫ 56 BH
⑨ 130 BH
⑩ 400 BH
⑯ 31 MC
⑱ 25 UN
⑨ 130 BH
⑩ 400 BH
LAND ㉒ 15 MC
LAND ㉓ 13 UN
⑨ 130 BH
⑩ 400 BH
⑬ 56 BH
⑨ 130 BH
⑩ 400 BH
⑲ 56 NR
⑨ 130 BH
⑩ 400 BH
LAND ㉔ 28 NR
⑨ 130 BH
⑩ 400 BH
⑳ 56 NR
⑨ 130 BH
⑩ 400 BH
㉑ 586 AO
⑭ 186 BH
⑧ 400 BH

NOTE For population served and influent loads, see Table 10-2
For character of emissions, see Table 10-3
For quantities of sludge produced, see Table 10-4

NSF Boston Case Study, Phase II Evaluation

SUMMARY OF ALTERNATIVES

Kennedy Engineers, Inc.
1977

Figure 10-5

Federal (75%), State (15%) and Local sectors. Table 10-6 lists responsiblity assuming the capital costs are 100 percent grant eligible, while Table 10-7 assumes reduced eligibility to 60.25%. As explained in the text, the degree of eligibility is based upon the assumption that the total flow for Alternative IC is the most cost-effective and that all other alternatives would be eligible on a percentage basis; that percentage being the ratio of the flow for Alternative IC to that for the alternative in Category II or III under consideration. This percentage is then applied to the total capital costs to determine the breakdown for funding.

For comparative purposes, Table 10-8 ranks the several alternatives on a monetary basis according to different criteria. Columns A-D of the table rank the alternatives, by increasing cost in terms of total cost (present worth), capital cost, annual O & M, and the local share of capital cost under assumed conditions of reduced eligibility for Federal and State funding.

Alternatives IA and IB have thirteen percent more allowance for industrial flows than the other alternatives.

Alternatives IIID and IIIG, incorporating land treatment systems for the satellite communities, would discharge less pollutants than other alternatives with satellite plant discharges to the rivers.

Systems utilizing advanced waste treatment are more costly and more susceptible to upsets.

Table 10- 2

INFLUENT LOADS AND POPULATIONS SERVED

Alternative	STP	Flow (mgd)	BOD		SS		NH_3-N		PO_4-P		Population
			mg/l	(1000) lb/day	mg/l	(1000) lbs/day	mg/l	(1000) lbs/day	mg/l	(1000) lbs/day	Served
I A, B	NI	115	176	169	253	243	--	--	--	--	735,435
	DI	215	204	365	204	365	--	--	--	--	1,305,332
	Total	330		534		608				Sub-total	2,040,767
I C	NI	136	193	219	277	315	--	--	--	--	952,900
	DI	212	226	399	226	399	--	--	--	--	1,425,084
	Total	348		618		714				Sub-total	2,377,984*
I D	NI	136	193	219	277	315	--	--	--	--	952,900
	DI	312	226	588.1	226	588.1	--	--	--	--	1,425,084
	Total	448		807.1		903.1				Sub-total	2,377,984
II A, B)	MC	31	222	57.4	183	47.4	21.0	5.43	12.0	3.10	181,000
III B, C, D)	UN	25.2	200	42.0	178	37.5	20.9	4.40	12.4	2.60	124,000
	NI	130	185	201.	259	281.	--	--	--	--	674,910
	DI	400	166	555.	153	511.	--	--	--	--	1,460,408
	Total	586.2		855.4		876.9				Sub-total	2,440,318
III A, J, & K	NI	186.2	194	300.4	236	365.9	--	--	--	--	979,910
	DI	400	166	555.	153	511.	--	--	--	--	1,460,408
	Total	586.2		855.4		876.9				Sub-total	2,440,318
III E, F, G &H	NEP	56.2	212	99.4	181	84.9	21.0	9.83	12.2	5.70	305,000
	NI	130	185	201.	259	281.	--	--	--	--	674,910
	DI	400	166	555.	153	511.	--	--	--	--	1,460,408
	Total	586.2		855.4		876.9				Sub-total	2,440,318

* Alternative IC would also serve 62,334 additional persons in 8 satellite communities outside the consolidated system, for a total of 2,440,318.

Table 10-3

CHARACTER OF EMISSIONS

Discharge Location	Alt.	Emission Number, Fig. 10-5	Plant Site	Flow, Mgd	Thousand pounds per day BOD	SS	N	P
Boston Harbor	IA	1	Nut I	115	120	109		
	IA	2	Deer I	215	219	172		
	IB	3	Nut I	115	170	102		
	IB	4	Deer I	215	215	146		
	IC-D	5	Nut I	136	149	129		
	IC	6	Deer I	212	235	160		
	ID	7	Deer I	212	341	235		
	IIIK	8	Deer I	400	339	245		
	II, IIIB-H	9	Nut I	130	30.2	32.6		
	II, IIIA-H	10	Deer I	400	83.2	76.6		
	IIIA	11	Nut I	186	44.3	45.3		
	IIIB	12	Satellite	56	14.1	12.7		
	IIIE	13	Mid Nep	56	14.1	12.7		
	IIIK	14	Nut I	186	216	168		
Middle Charles River	II	15	Mid Chars.	31	1.3	1.3	0.26	0.26
	IIIC	16	Mid Chars.	31	7.8	7.1	3.80	2.17
	IIID	22	Land	16	0.4	0.9	0.08	0.01
Upper Neponset River	II	17	Up. Nep.	25	1.0	1.0	0.21	0.21
	IIIC	18	Up. Nep.	25	6.3	5.6	3.08	1.82
	IIID	23	Land	13	0.3	0.7	0.06	0.01
Middle Neponset River	IIIF	19	Mid. Nep.	56	14.1	12.7	6.88	4.00
	IIIH	20	Mid. Nep.	56	2.3	2.3	0.47	0.47
	IIIG	24	Land	28	0.7	1.6	0.14	0.01
Atlantic Ocean	IIIJ	21	Deer&Nut	586	555	413		

Notes: This table is not intended to indicate the environmental effect of future discharges.

For comparison, the FY 7576 discharges are reported to be as follows:

Locations	Plant	Flow mgd	Thousand pounds per day BOD	SS
Boston Harbor	Nut I	123	124	116
	Deer I	329	260	210
Total		452	384	326

Table 10-4

QUANTITIES OF SLUDGE PRODUCED

(thousand pounds per day at plant site)

Alternative	Middle Charles River	Upper Neponset River	Middle Neponset River	Nut Island	Deer Island	TOTAL
I A	*	*	*	134	194	328
I B	*	*	*	141	219	360
I C	*	*	*	186	239	425**
I D	*	*	*	186	353	539
II A	72	58	*	210	478	818
II B	72	58	*	210	478	818
III A	*	*	*	290	478	768
III B	44	36	*	210	478	768
III C	44	36	*	210	478	768
III D	0	0	*	210	478	688
III E	*	*	80	210	478	768
III F	*	*	80	210	478	768
III G	*	*	0	210	478	688
III H	*	*	130	210	478	818
III J	*	*	*	198	266	464
III K	*	*	*	198	266	464

* There would be no plant at the sites noted by an asterisk.

** Does not include sludge from the 62,334 persons in 8 communities served by septic tanks.

Table 10-5

MONETARY COST SUMMARY
MILLION

	Alternative	Capital Cost	Annual O & M	Present Worth
I A	Upgrade, Present Serv. Area	$404.8	$ 9.9	$238.4
I B	Upgrade, Present Serv. Area	$417.6	$11.2	$248.1
I C	Upgrade, Expand Service Area	$489.0	$12.3	$286.7
II A	EMMA Recommended Plan	$855.4	$25.6	$603.0
II B	EMMA W/STP Additions	$959.6	$39.3	$653.3
III A	No Satellite Plants	$872.4	$21.2	$582.4
III B	Two Satellite Secondary Plants, Effluent to Boston Harbor	$842.5	$22.7	$581.2
III C	Two Satellite Secondary Plants, Effluent to Rivers	$810.0	$22.5	$563.0
III D	Two Satellite Land Treatment Plants	$842.3	$22.4	$576.1
III E	One Satellite Secondary Plant, Effluent to Boston Harbor	$843.2	$22.3	$575.8
III F	One Satellite Secondary Plant, Effluent to Neponset River	$819.9	$22.2	$564.1
III G	One Satellite Land Treatment Plant	$853.4	$22.4	$582.7
III H	One Satellite AWT Plant, Effluent to Neponset River	$855.5	$24.6	$597.6
III J	Primary Treatment, Effluent to Ocean, no Satellite	$737.8	$17.2	$475.7
III K	Primary Treatment, Present Discharge, No Satellite	$581.5	$15.4	$390.9

Note: It can be observed that alternatives IIIA - IIIH are within 7% of alternative IIA. This is primarily due to all category II and III alternatives being sized to handle 586 mgd.

Table 10-6

PROJECT COSTS, ALTERNATIVES I, II & III (100% GRANT ELIGIBILITY)

(Million Dollars)

ALTERNATIVE	LOCAL Cap. Cost	LOCAL O&M	STATE Cap. Cost	FEDERAL Cap. Cost	TOTAL Cap. Cost
I A Upgrade, Present Service Area	$ 40.48	$ 9.91	$ 60.72	$303.59	$404.79
I B Upgrade, Present Service Area	$ 41.76	$11.20	$ 62.64	$313.17	$417.57
I C Upgrade Expand Service Area	$ 48.90	$12.25	$ 73.35	$366.73	$488.98
II A EMMA	$ 85.54	$25.57	$128.31	$641.59	$855.36
II B EMMA with additions	$ 95.96	$39.28	$143.94	$719.70	$959.60
II A Eligibility $\frac{Q_{IC}}{Q_{IIA}}$	$391.50	$25.57	$ 77.30	$386.56	$855.36
III A No Satellite Plants	$ 87.2	$21.2	$130.9	$654.3	$872.4
III B Two Satellite Secondary Plants, Effluent to B.H.	$ 84.3	$22.7	$126.4	$631.8	$842.5
III C Two Satellite Plants, Effluent to Rivers	$ 81.0	$22.5	$121.5	$607.5	$810.0
III D Two Satellite Land Treatment Plants	$ 84.2	$22.4	$126.3	$631.7	$842.3
III E One Satellite Secondary Plant, Effluent to B.H.	$ 84.3	$22.3	$126.5	$632.4	$843.2
III F One Satellite Secondary Plant,Effluent to Nep.R.	$ 82.0	$22.2	$123.0	$614.9	$819.9
III G One Satellite Land Treatment Plant	$ 85.3	$22.4	$128.0	$640.1	$853.4
III H One Satellite AWT Plant, Effluent to Nep. Riv.	$ 85.6	$24.6	$128.3	$641.6	$855.5
III J Primary Treatment Effluent to Ocean, No Satellite	$ 73.8	$17.2	$110.7	$553.4	$737.8
III K Primary Treatment, Present Discharge, No Satellite	$ 58.2	$15.4	$ 87.2	$436.1	$581.5

Table 10-7

ASSUMED GRANT ELIGIBLE COSTS
(millions)

ALTERNATIVE		LOCAL		STATE	FEDERAL	TOTAL
		Cap. Cost	O&M	Cap. Cost	Cap. Cost	Cap. Cost
IA	Upgrade	$ 40.5	$ 9.9	$ 60.7	$303.6	$404.8
IB	Upgrade	$ 41.8	$11.2	$ 62.6	$313.6	$417.6
IC	Upgrade/Expand	$ 48.9	$12.3	$ 73.4	$366.7	$489.0
IIA	EMMA	$391.5	$25.6	$ 77.3	$386.6	$855.4
IIB	EMMA with additions	$439.2	$39.3	$ 86.7	$433.7	$959.6
IIIA	No Satellite Plants	$399.4	$21.2	$ 78.8	$394.2	$872.4
IIIB	Two Satellite Secondary Plants, Effluent to Boston Harbor	$385.7	$22.7	$ 76.1	$380.7	$842.5
IIIC	Two Satellite Plants, Effluent to Rivers	$370.8	$22.5	$ 73.2	$366.0	$810.0
IIID	Two Satellite Land Treatment Plant	$385.6	$22.4	$ 76.1	$380.6	$842.3
IIIE	One Satellite Secondary Plant Effluent to Boston Harbor	$386.0	$22.3	$ 76.2	$381.0	$843.2
IIIF	One Satellite Secondary Plant, Effluent to Neponset Riv.	$375.3	$22.2	$ 74.1	$370.5	$819.9
IIIG	One Satellite Land Treatment Plant	$390.6	$22.4	$ 77.1	$385.7	$853.4
IIIH	One Satellite AWT Plant, Effluent to Neponset R.	$391.6	$24.6	$ 77.3	$386.6	$855.5
IIIJ	Primary Treatment, Effluent to Ocean, No Satellite	$337.1	$17.2	$ 66.7	$333.4	$737.8
IIIK	Primary Treatment Present Discharge, No Satellite	$266.1	$15.4	$52.6	$262.8	$581.5

Note: This table assumes 60.25% eligibility for all alternatives except IA, IB, and IC.

Table 10-8

MONETARY RANKING OF ALTERNATIVES

	A. PRESENT WORTH		B. CAPITAL COST		C. ANNUAL O & M COST		D. LOCAL SHARE OF CAPITAL**	
	Alternative	million	Alternative	million	Alternative	million	Alternative	million
1.	I A*	$238.4	I A*	$404.8	I A*	$ 9.9	I A*	$ 40.5
2.	I B*	$248.1	I B*	$417.6	I B*	$ 11.2	I B*	$ 41.8
3.	I C*	$286.7	I C*	$489.0	I C*	$ 12.3	I C*	$ 48.9
4.	III K*	$390.9	III K*	$581.5	III K*	$ 15.4	III K*	$266.1
5.	III J*	$475.7	III J*	$737.8	III J*	$ 17.2	III J*	$337.1
6.	III C	$563.0	III C	$810.0	III A	$ 21.2	III C	$370.8
7.	III F	$564.1	III F	$819.9	III F	$ 22.2	III F	$375.3
8.	III E	$575.8	III D	$842.3	III E	$ 22.3	III D	$385.6
9.	III D	$576.1	III B	$842.5	III G	$ 22.4	III B	$385.7
10.	III B	$581.2	III E	$843.2	III D	$ 22.4	III E	$386.0
11.	III A	$582.4	III G	$853.4	III C	$ 22.5	III G	$390.6
12.	III G	$582.7	II A	$855.4	III B	$ 22.7	II A	$391.5
13.	III H	$597.6	III H	$855.5	III H	$ 24.6	III H	$391.6
14.	II A	$603.0	III A	$872.4	II A	$ 25.6	III A	$399.4
15.	II B	$653.3	II B	$959.6	II B	$ 39.3	II B	$439.2

* Provides less than secondary treatment.

II A = EMMA Recommended Plan

** Local Share Cost in Column D is based on assumed 60.25% fundability for all Alternatives in Categories II and III. (The flow of Alternative IC is 60.25 percent of the flows of Alts. II and III).

G. SUMMARY OF CHAPTER 10

1. In this case study, three categories of Alternatives have been presented and analyzed:

(a) Category I

A basic program to upgrade existing wastewater facilities is proposed with arbitrary limitations for service area, population growth, and flow allowances and other criteria. The purpose of these alternatives is to determine the size and cost of facilities including sewer repair based on amount of flow and service area expansion, but excluding secondary treatment.

(b) Category II

The proposed wastewater management plan for the Boston Harbor-Eastern Massachusetts area, known as the EMMA Recommended Plan is analyzed to determine the cost-effectiveness of its facility size.

The options in Category II include increased primary treatment and funding of the EMMA plan with possibly reduced grant fundability.

(c) Category III

Ten Alternatives to the EMMA Recommended Plan are presented to indicate costs and impacts of various configurations of sub-regional systems, four treatment levels, and five discharge locations.

2. The locally proposed plan for wastewater management in the Boston Metropolitan area, Alternative II A, is estimated to cost $855.4 million. Most of this amount is planned for treatment and disposal and does not include sewers or sewer rehabilitation. Seventy-five percent of the capital cost is ordinarily funded by a Federal grant and, in the Commonwealth of Massachusetts, and additional fifteen percent is funded

by a State grant. The basic alternatives of upgrading the existing facilities, are developed with the following constraints:

(a) The service area is not expanded, and the growth in the existing service area is limited to thirty percent, (Alternatives IA and IB only).

(b) The per capita domestic wastewater flows are reduced from the higher proposed amounts to 85 gallons per day or to the present amount, whichever is less,

(c) The excessive infiltration inflow is reduced to 30 gallons per capita per day which is one-fourth of that proposed, and

(d) Secondary treatment is not provided.

Alternative IC, developed without growth constraints, costs approximately onehalf as much as the EMMA Plan.

3. The flow to be treated in accordance with the constraints in Alternative IC is 348 mgd. The flow to be treated in the Category II and III Alternatives is the same as that projected in the EMMA Study, 586 mgd, of which 577 mgd is from existing member communities. The ratio of these flows is 0.6025 or 60.25 percent. This ratio is used in the next summary paragraph of this Case Study to compute the portion of the project captial cost considered grant eligible.

4. The data tabulated below list the costs of the EMMA Recommended Plan, Alternative IIA. The first column represents costs based on the current funding policy.

The second column represents revised costs under specific constraints as developed in this Case Study.

The third column represents savings in the amount of grants (-), or the additional local share (+).

	Million Dollars		
	100% Eligibility	60.25% Eligibility	Difference
Project Capital Cost	$855.4	$855.4	
Eligible Capital Cost	855.4	515.4	
Ineligible Capital Cost	0	340.0	
Federal Grant (75% of Eligible Cost)	641.6	386.6	$-255.
State Grant (15% of Eligible Cost)	128.3	77.3	- 51.
Local Share Capital Cost (10% of Eligible Cost) plus 100% of Ineligible Cost)	85.5	391.5	+306.
Local Share Annual O&M (100% of annual O&M)	25.6	25.6	

This case study indicates that appropriate facilities planning can reduce the scope of new wastewater projects. To optimize planning efficiency, federal guidelines are needed.

REFERENCES

10.1 Metcalf & Eddy, Inc., et al/MDC
"Wastewater Engineering and Management
Plan for Boston Harbor - Eastern
Massachusetts Metropolitan Area - EMMA Study"
Main Report, Appendices, and Summary, 1975-76.

10.2 Martin Weiss and Jekabs P. Vittands,
"Wastewater Engineering and Management
Plan for Boston Harbor"
Presented at WPCF 49th annual
Conference October 3-8, 1976, Minneapolis,
Minnesota.

10.3 Carroll Leslie Bastian, Federal Interagency
Study Team Program Manager,
National Science Foundation
Conversations in Boston with local, state
and EPA officials and William A. Anderson,
Kennedy Enginners
November 1, 1976.

10.4 EPA (Facility Requirements Branch)
"Grants for Construction of Treatment Works,
Cost Effectiveness Analysis Guidelines"
Amended proposed supplement to 40 CFR,
Part 35, Subpart E - Appendix A. Federal
Register Vol. 42, No. 24, February 4, 1977.

10.5 Massachusetts DWPC & Region I EPA
NPDES Permit to MDC
MA 0102351/M44/M180
Issued August 12, 1976, effective 45 days
thereafter
Expires May 1, 1991
Modified by ECSL August 11, 1976.

10.6 Massachusetts DWPC, Westborough, Mass.
"Classification and Segmentation
of Massachusetts River Basins and
Coastal Zones"
May 1976, No. 8933-223-100-5-76 CR.

DRAFT REPORT DISTRIBUTION LIST

Mr. Thomas C. Jorling
Assistant Administrator for Water
and Hazardous Materials
Environmental Protection Agency
401 M Street, S.W. (WH-546)
Washington, D.C. 20460

Mr. John T. Rhett
Deputy Assistant Administrator
for Water Program Operations
Environmental Protection Agency
401 M Street, S.W. (WH-546)
Washington, D.C. 20460

Mr. Harold Cahill
Director
Municipal Construction Division
Environmental Protection Agency
401 M Street, S.W. (WH-547)
Washington, D.C. 20460

The Hon. J. Gustave Speth
Council on Environmental Quality
722 Jackson Place, N.W.
Washington, D.C. 20006

Mr. William R. Adams, Jr.
Regional Administrator
U.S. Environmental Protection Agency
Region I, J. F. Kennedy Building
Boston, Massachusetts 02203

Mr. Lester A. Sutton
Director, Water Programs
U.S. Environmental Protection Agency
Region I, J. F. Kennedy Building
Boston, Massachusetts 02203

Mr. Wallace E. Stickney, Director
Environmental Policy Coordination Office
U.S. Environmental Protection Agency
Region I, J. F. Kennedy Building
Boston, Massachusetts 02203

Mr. Stephen Ells
Congressional and Intergovernmental Relations
U.S. Environmental Protection Agency
Region I, J. F. Kennedy Building
Boston, Massachusetts 02203

Ms. Mary Shaughnessy
U.S. Environmental Protection Agency
Region I, J. F. Kennedy Building
Boston, Massachusetts 02203

Commissioner John F. Snedeker
Metropolitan District Commission
20 Somerset Street
Boston, Massachusetts 02108

Mr. Allison C. Hayes, Director of Sewerage
Division & Chief Sewerage Engineer
Metropolitan District Commission
20 Somerset Street
Boston, Massachusetts 02108

Mr. Martin Weiss
Chief Engineer
Metropolitan District Commission
20 Somerset Street
Boston, Massachusetts 02108

Commissioner David Standley
Dept. of Environmental Quality Engineering
Division of Water Pollution Control
Leverett Saltonstall Building
100 Cambridge Street
Boston, Massachusetts 02202

Mr. Thomas C. McMahon, Director
Massachusetts Division of
Water Pollution Control
110 Tremont Street
Boston, Massachusetts 02108

Mr. Richard F. Greeley
Division of Water Pollution Control
110 Tremont Street
Boston, Massachusetts 02108

Mr. Alan Cooperman
Division of Water Pollution Control
Leverett Saltonstall Building
100 Cambridge Street
Boston, Massachusetts 02202

Director of Environmental Planning
Metropolitan Area Planning Council
44 School Street
Boston, Massachusetts 02108

Mr. Joseph M. McGinn
Metropolitan Area Planning Council
44 School Street
Boston, Massachusetts 02108

Mr. James A. O'Rourke
Public Works Department
Sewer Division
Rm. 716, City Hall
1 City Hall Square
Boston, Massachusetts 02201

Mr. James Callahan
Chief, Urban Studies Branch
Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02154

New England Interstate Water
Pollution Control Commission
607 Boylston Street
Boston, Massachusetts 02116

Dr. John R. Ehrenfeld
New England River Basins Commission
55 Court Street
Boston, Massachusetts

Senator William M. Bulger
Special Commission on
Pollution of Boston Harbor
State House, Rm. 321
Boston, Massachusetts 02133

Mr. Leo Allen
Staff Assistant
Special Commission on Pollution
of Boston Harbor
State House, Rm. 321
Boston, Massachusetts 02133

Mr. Waldo Holcombe, Chairman
Citizens Advisory Committee
c/o Metropolitan Area Planning Council
44 School Street
Boston, Massachusetts 02108

Mrs. Lydia Goodhue
Chairman, Boston Harbor Citizens
Advisory Committee
90 Dover Road
Wellesley, Massachusetts 02181

Dr. A. Richard Miller
Executive Director
Lake Cochituate Watershed Association
61 Lakeshore Road
Natick, Massachusetts 01760

Mr. Jim Tozzi
Office of Management and Budget
New Executive Office Building, Rm. 8222
726 Jackson Place, N.W.
Washington, D.C. 20503

Mr. John Kingscott
Environmental Protection Agency
401 M Street, S.W. (WH547)
Washington, D.C. 20460

David Tundermann
Council on Environmental Quality
New Executive Office Bldg., Rm. 5001
722 Jackson Place, N.W.
Washington, D.C. 20006

+ Mrs. Carroll Leslie Bastian
Policy Research and Analysis
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

Mr. Richard E. Morrison
Policy Research and Analysis
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

Mr. Robert M. Kennedy
Kennedy Engineers, Inc.
657 Howard Street
San Francisco, California 94105

Mr. William A. Anderson
Kennedy Engineers, Inc.
657 Howard Street
San Francisco, California 94105

++ Dr. J. Douglas Smith
Environmental Research & Technology, Inc.
696 Virginia Road
Concord, Massachusetts 01742

+++ Dr. Samuel Fogel
Environmental Research & Technology, Inc.
696 Virginia Road
Concord, Massachusetts 01742

Mr. James Hudson
Urban Systems Research &
Engineering, Inc.
1218 Massachusetts Avenue
Cambridge, Massachusetts 02138

Professor David H. Marks
Consultant
Resource Analysis Incorporated
Room 48-305, M.I.T.
Cambridge, Massachusetts 02139

Mr. Jerome Horowitz
The Vertex Corporation
2401 Research Boulevard
Rockville, Maryland 20850

Ms. Libby Blank, Director of
Environmental Planning
Metropolitan District Commission
20 Somerset Street
Boston, Massachusetts 02108

Dr. Evelyn Murphy
Secretary of Environmental Affairs
Leverett Saltonstall Building
100 Cambridge Street
Boston, Massachusetts 02202

James Loundsbury
Office of Management and Budget
New Executive Office Building
Washington, D.C. 20503

+ Mrs. Bastian is currently at the Council on Environmental Quality

++ Dr. Smith is currently a consultant at 549 N.W. Inlet Ave., Lincoln City, Oregon 97367

+++ Dr. Fogel is currently at J.B.F. Scientific, 2 Jewel Drive, Wilmington, Mass. 01887

NOTE: Additional copies were made available during the review period and were distributed to citizens and other interested parties.

COMMENTS

Draft Report Public Review

Draft copies of this report were delivered to the Federal Interagency Study Team May 1978. The draft report was reviewed and approved August 1978 for distribution with the three companion reports. Approximately fifty copies were mailed to various agencies involved with facilities planning. Copies were also sent to concerned citizens, and additional copies were made available to other interested parties requesting them.

Public Participation

A series of meetings was held in Boston in September 1978 on the four case study reports. The reports were the subject of several newspaper articles and television reports.

A public hearing was held in the John F. Kennedy Center September 27, 1978, chaired by Dr. Evelyn Murphy, Secretary of the Executive Office of Environmental Affairs of the Commonwealth of Massachusetts. Statements were made by representatives of:

EPA Region I
Metropolitan District Commission
Massachusetts Division of Water Pollution Control
Metropolitan Area Planning Council
Independent Coalition of Citizens Groups
Executive Office of Environmental Affairs
Kennedy Engineers, Inc.
Environmental Research & Technology, Inc.
  (Water Quality Goals and Objectives)
Environmental Research & Technology, Inc.
  (Sludge Management)
Urban Systems Research & Engineering, Inc.

Twelve speakers from the audience presented their viewpoints. Several represented citizens groups. Written comments were requested by the Federal Interagency Study Team. The availability of the draft reports was again announced.

Comments

Written comments were received from twenty interested parties. The written comments can generally be categorized as follows: Comments from private parties and citizens groups were quite supportive of the case study; comments from public agencies tended to be critical of the case study. All comments received have been considered in the preparation of the final report. The report has been annotated and augmented as appropriate.

Discussion

The major focus of criticisms concern failures of the case study reports to recognize the planning changes occuring after 1976. Footnotes have been added which cite important subsequent developments, however it is beyond the scope of this study to update it to include development up to final publication. It is again emphasized that this case study records observations on the wastewater situation in the Boston Metropolitan Area through the first four years of Public Law 92-500 (1973-1976).

Comments from several reviewers indicate that the study team's comments regarding EPA Region I's committment to follow the EMMA Plan is overstated.

The case study reports were also criticized for reviewing the EMMA Study with the assumption that the EMMA Recommended Plan has been accepted for implementation. Among the sources that led the Federal Interagency Study team to reach this conclusion were the reference to compliance with the EMMA Plan in NPDES permit and the Enforcement Compliance Schedule Letter (ECSL) dated August 11, 1976 signed by EPA, DWPC, and MDC, and the September 13, 1976 approval by EPA of the EMMA report as the Basin Plan. Those documents together with published information packages and news releases by EPA in 1976 that announced agreement on a construction project to improve MDC facilities indicated adoption of the EMMA Plan for implementation.

The draft EIS on the Upgrading of the Boston Metropolitan Area Sewerage System (August 4, 1978) eliminated the concept of satillite treatment systems for water quality reasons, found the Nut Island Facilities should be demolished and relocated elsewhere, states that excessive I/I exists in both the local sewers and in the MDC interceptors, and recommends that water conservation be employed. We concur with those findings. As predicted however, we believe the draft EIS suffered from lack of a comprehensive Project Report and from limitations of scope of work due to predetermination of certain project elements.

Comments were also received regarding flow quantities. The case study does not claim to predict actual wastewater flows; it merely observes that local planning anticipated increased per capita flows. The case study does however show how much smaller the grant eligible portion of facilities could be if grants were based on flow limits for funding purposes. It should be mentioned again that present wastewater flows are not known, nor even total flows including wastewater and I/I, because of upstream overflows, unmeasured by-passes and intentional flow restrictions, some of which occur during dry weather.

The cost allowance for rehabilitation and replacement of sanitary sewers was questioned. Estimated costs were taken from national sources and were adjusted to the date of the case study price level. The costs represent average conditions and are believed ample for collection system work in the suburban communities. In the densely developed areas, costs are also believed to be ample for rehabilitation. Costs may be somewhat low to replace sewers of equal size but replacement sizes may be smaller when excessive flow is reduced. It should be noted that sanitary sewers are relatively small when compared to combined sewers. It should also be recognized that many 50 to 100 year old sewers have reached their useful life. There is a need to replace failed sewers whether or not there is excessive I/I, and whether or not there is a construction grant program.

We have again reviewed the available data on the Cottage Farm Combined Sewer Station, and believe the data support our finding that the facility will be ineffective in significantly reducing pollution at rated design capacity.

It is recognized that state, regional, and local agencies in the study area have publicly opposed secondary treatment for many years as not measurably producing water quality benefits and that only the influence of EPA caused it to be included in local planning.

A pertinent comment received was that the Engineering Report:

> "hints at a series of programs and a sequencing of projects to reduce wastewater flows requiring treatment, which are beyond MDC's jurisdiction and contrary to federal law."

We believe federal law does not prohibit wastewater management crossing boundaries of local jurisdictions; in fact regulations say the treatment works grant applicant is responsible for the entire sewer system tributary to the treatment works, not limited by political jurisdictions. We believe it is clearly intended that the entire water quality management problem be addressed, disregarding who might be the project implementation agency.

An additional comment received said:

> "The construction grants program, though well intended, has tended to lose sight of its water quality objectives through its focus on treatment facilities."

We concur with this comment and do not believe that EPA is mandated to provide facilities such as secondary treatment in priority to facilities which are identified as the most effective in benefiting water quality.

On December 27, 1977, the Congress enacted the Clean Water Act of 1977 (PL 95-217), which provides:

a. Long term funding for program stability,
b. Flexibility, with emphasis on alternatives for small or rural communities and allowance for waivers of ocean discharges,
c. Increased state role,

d. Incentives for conservation, innovation, and alternative technology, and
e. Greater emphasis on control of toxic pollutants.

More than fifty significant regulatory changes will affect water pollution control activities. Included are new cost-effectiveness guidelines which will limit grant eligible sizes of facilities, and provisions for modifying secondary treatment requirements for existing discharges from publicly owned treatment works into deep ocean waters. A section specifically for the study area is that EPA shall reimburse the City of Boston up to $15,000,000 to relocate the Deer Island prison if the site is used for a secondary treatment plant.

On September 27, 1978, the EPA published new rules and regulations for the construction grants program, effective October 1, 1978.

Acknowledgements

We acknowledge the cooperation and assistance provided by the EPA Region I, the Commonwealth of Massachusetts DWPC, the MAPC, the Metropolitan Sewerage Division of the MDC, the City of Boston, and a number of consulting engineers and citizens groups.

Andrew P. Fisichelli, Robert J. Holthaus, and James W. Connell of MDC were very helpful during our visits to facilities. We are grateful to Lester A. Sutton and his staff at EPA Region I. Daniel K. O'Brien, Bernard R. Sacks and William J. Butler extended noteworthy assistance in providing data to us.

Camp, Dresser & McKee, Metcalf & Eddy, C.A. McGuire, and Dames & Moore loaned us copies of reports and made other data available.

We enjoyed working with our colleagues on this case study and particularly cite the cooperation of Jim Hudson, Sam Fogel, Jack Smith, Tom Kalinowski, and Jerome Horowitz.

We appreciate very much the opportunity to have participated in this case study. The Federal Interagency Study Team members that we worked with most were: Keith H. Dearth and John Kingscott (EPA), Marilyn W. Klein (CEQ), Jim J. Tozzi (OMB), and Carroll Leslie Pegler (Mrs. Robert K. Bastian) and Richard E. Morrison (NSF).

Robert M. Kennedy
William A. Anderson

6089

San Francisco, January 18, 1979